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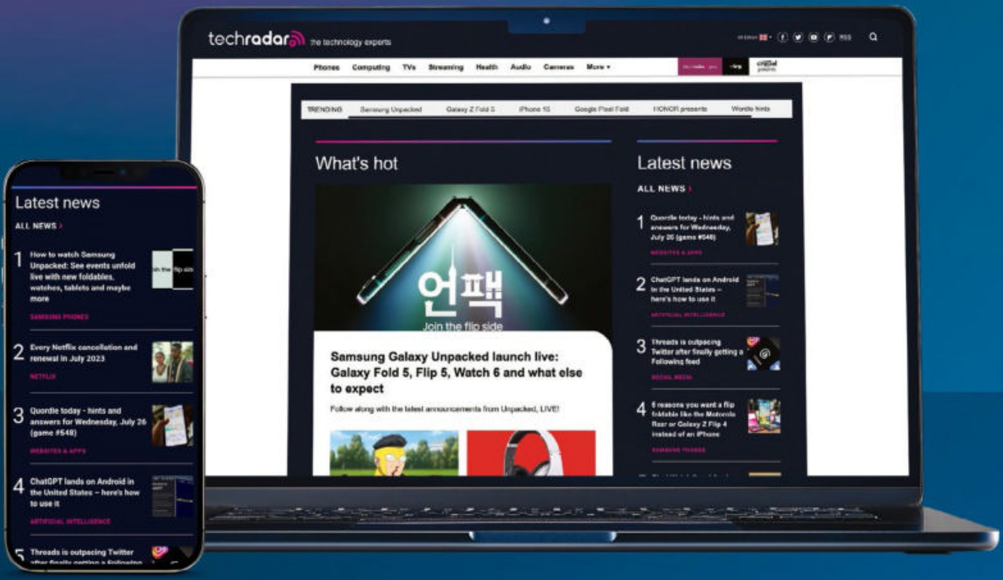
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Contributing Writers: Jon Bailes, Nate Drake, Ian Evenden, Dave James, Nathan Jordan, Jeremy Laird, Chris Lloyd, Nick Peers, Nik Rawlinson, Jacob Ridley, Zak Storey, Chris Szewczyk, Jarred Walton
Production Editor: Steve Wright
Editor Emeritus: Andrew Sanchez

ART
Art Editor: Fraser McDermott
Photography: Neil Godwin, Olly Curtis, Phil Barker
Cover Photo Credits: Apple Corp, Getty Images, AMD, Future PLC

BUSINESS
US Marketing & Strategic Partnerships: Stacy Gaines, stacy.gaines@futurenet.com
US Chief Revenue Officer: Mike Peralta, mike.peralta@futurenet.com
East Coast Account Director: Brandie Rushing, brandie.rushing@futurenet.com
East Coast Account Director: Michael Plump, michael.plump@futurenet.com
East Coast Account Director: Victoria Sanders, victoria.sanders@futurenet.com
East Coast Account Director: Melissa Planty, melissa.planty@futurenet.com
East Coast Account Director: Elizabeth Fleischman, elizabeth.fleischman@futurenet.com
West Coast Account Director: Austin Park, austin.park@futurenet.com
West Coast Account Director: Jack McAuliffe, jack.mcauliffe@futurenet.com
Director, Client Services: Tracy Lam, tracy.lam@futurenet.com

MANAGEMENT
CEO: Jon Steinberg
MD Tech: Paul Newman
Group Editor-in-Chief: Graham Barlow
Group Art Director: Warren Brown

PRODUCTION
Head of Production: Mark Constance
Senior Production Manager: Matthew Eglinton
Production Manager: Vivienne Calvert
Production Assistant: Emily Wood

Future US LLC, 130 West 42nd Street,
7th Floor, New York. NY 10036. USA. www.futureus.com

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Guy
Cocker

IT'S ALL COMING TOGETHER

IF NVIDIA'S RTX 4070 Super took center stage last issue, this month, it's the turn of its slightly superior sibling, the RTX 4070 Ti Super. If you can look past the silly name, the big attraction with the Ti Super is that it gets an upgrade to Nvidia's fancier AD103 silicon. That means extra CUDA cores, a wider memory bus, and a chunk more GDDR7.

Consequently, it's better equipped to make the leap from 1440p gaming to full 4K. It's also more expensive, with a $200 premium over the 4070 Super. Is it worth the extra cash? Turn to page 74 and Zak's review to find out. Our former editor has likewise leant into the 4070 Ti Super for this month's build from page 16. Will it prove as compelling as last month's $2K 4070 Super rig?

Speaking of builds, Zak has also been busy compiling part two of his definitive dissertation on that very subject. The second installment of The Ultimate PC Build Guide features everything from custom cabling conundrums and bork-free BIOS updates to measures to avoid melting GPUs and final stress testing. Turn to page 44 to complete your masterclass and finally attain zen-like levels of PC building prowess.

Our final build-related feature for this issue is Nick Peers' eight-page magnus opus on NAS storage. Nick has compiled the most forensic, comprehensive, and user-friendly guide to building and setting up your own Network Attached Storage server you could imagine. If you've been intimidated by what superficially seems like a high-tariff task, Nick's guide from page 32 is what you've been waiting for.

Of course, the opposite of building something is tearing it apart, and this month we have an insight into the innards of Apple's new headset on page 60. The Vision Pro is silly money at $3,500, but you can't deny that it's technically interesting, and its inner workings laid bare in our full teardown are fascinating. Anyway, the first batch of around 200,000 units reportedly sold out fast, so we'd welcome it purely for supercharging public interest in AR/VR.

As for other highlights, our GPU guru Jarred has turned his gaze toward integrated graphics. The holy grail for GPUs built into CPUs is to achieve genuine gameability. Discover from page 52 if the latest efforts from AMD and Intel can finally achieve that aim.

Over in the reviews section from page 74, along with the 4070 Ti Super, we have both AMD's new budget GPU, the Radeon RX 7600 XT and its new desktop APU with its own fairly powerful GPU in the Ryzen 8700G. Meanwhile, Dough's dynamite 4K panel gets a Gorilla glass upgrade and we take Lenovo's fabulous new handheld gaming PC for a spin.

We've also got the lowdown on what might be the most fun you can have with your PC this year. Yup, it's our review of *Helldivers 2*, the second coming of the seminal sci-fi squad shooter. Add our usual quartet of how to's from page 62, including getting the most out of the new Nvidia app and open-source password managers, and this month really is *Maximum PC* at its very best.

Enjoy the issue!

Guy Cocker

Guy is Maximum PC's *editor-in-chief. He built his first gaming PC in 1997 to play* Tomb Raider *on 3dfx, and has been obsessed with all things PC ever since.*

↘ submit your questions to: editor@maximumpc.com

THE NEWS

Intel's new monster

New world's fastest processor reaches 6.2GHz

INTEL'S 14th generation is to be joined by the Intel Core i9-14900KS Special Edition, which buzzes along at a maximum boost speed of 6.2GHz, breaking the 6GHz barrier and becoming the world's fastest processor. The base clock is a more pedestrian 3.2GHz. Otherwise, it's the same chip as the 6.0GHz i9-14900K, so we have 24 cores, with eight performance and 16 efficiency cores, for a grand total of 32 threads. It draws more power at 300W-400W, compared to the K chip's maximum Turbo Power draw of 253W. This is a lot of power, with liquid cooling advised, if not required.

Intel is keen to show off its shiny foundries, as it plans to become a major foundry at the forefront of processor technology.

© INTEL

Samples have appeared online, including running all its performance cores at 5.9GHz. It had an average temperature of 96 C, with a peak of 101 C, and managed an average power draw of 330 W, peaking just shy of 410 W. Apparently, Intel has had to fiddle with core voltages to reach such heights, bumping it to 1.5 volts, and it shows. The cost of its gaming prowess is reportedly $749, a full $160 extra for 200MHz. We want one, because who wouldn't want to be running this if they could? Expect a new round of benchmark records when people who like that sort of thing get hold of them.

Intel has done this before. When you're waiting for the next generation to drop, and the current one is mature, you can hit the binning process hard and sift through wafers looking for the most stable ones. Test these until you find enough that can withstand high frequencies. Release the result as a halo gaming chip, and capture the records and headlines. It's a bit of marketing flimflam, really, as it deflects from the fact that we're waiting to see Intel produce something really flashy. The last range of chips were a plain refresh, tweaking a few clock speeds, and christening them 14th generation in the processes. This was a cheeky move. The Raptor Lake core is technically a refresh of the Alder Lake core from the 12th generation. At least Intel engineers have managed to squeeze a lot of performance out of the design.

The next big thing will be Arrow Lake, and with that the 20A process. This isn't just a shrink, as it introduces two important technologies that Intel is counting on—backside power, or PowerVia in the official Intel lingo, and a new type of transistor, RibbonFET. PowerVia moves the power delivery to the other side of the chip, giving things more room, so you can get more transistors in the same space. RibbonFET (ribbon field effect transistors) are smaller and faster than the previous technology.

Arrow Lake will also make the jump to a tile-based design for desktops. Intel has confirmed that it will use 3nm GPU tiles made by TSMC, while the processing tiles will launch Intel's 20A process. It appears that there will be quite a lot of TSMC silicon inside Arrow Lake, which is ironic, given Intel's ambitions as a foundry, but capacities are tight. The desktop and mobile versions will have a unified naming system, which is apparently Core Ultra Series 2.

Apart from some basic information, details are hard to find. There are plenty of rumors, though. A consistent one is that Intel will ditch hyper-threading. A test system sporting an alpha silicon 24-core Arrow Lake chip has been spotted with eight performance and 16 efficiency cores, but only 24 threads. That doesn't mean the idea has been ditched, though, as Intel has patents on a system to run parallel instructions on hybrid cores. HT may also have been disabled for stability.

We expect Arrow Lake to just make a limited appearance this year, with serious production numbers not being reached until next year. It could be a while before the mighty i9-14900KS gets bested. Until then, if you must have the best there is, Intel has once again provided a monster chip for your gaming rig. What's not to like? **–CL**

> “Expect a new round of benchmark records when people get hold of them

AI ROBOT ATTRACTS BIG INVESTORS

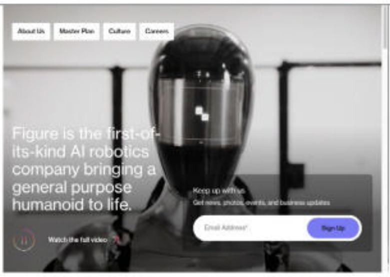
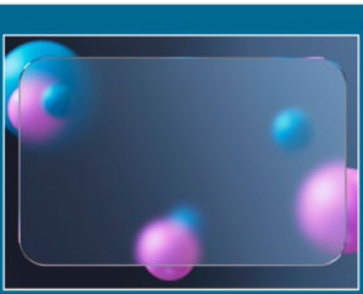


Figure is the first-of-its-kind AI robotics company bringing a general purpose humanoid to life.

FIGURE AI is a start-up robotics company that has attracted investments of $675 million from such players as Microsoft, Nvidia, Intel, OpenAI, and Jeff Bezos himself. The robot, Figure 01, is billed as an autonomous AI-powered multi-purpose humanoid robot suitable for dangerous and undesirable tasks. As soon as you see one, you think of the Terminator. At least it doesn't have a skull for a face, although Figure AI's website does have a section called 'master plan', along with a lot of jargon, mission statements, and 'visions'. The ominous appearance is somewhat undercut when you see it move, as it shuffles about like an octogenarian. Tesla is working on a similar machine, Optimus Gen-1, so it looks as if something along these lines will come to market in the near future. **–CL**

TRANSPARENT LAPTOP



LENOVO has proved rumors true and built a laptop with a transparent screen. The augmented reality machine is just a concept for now, but has an undeniable cool factor. The screen is 55 percent transparent when the pixels are off—switched on, they become increasingly opaque, but never completely. It has a modest 720p resolution, and the keyboard is a flat piece of glass with a projected layout. This looks good, but isn't easy to type on. As for what can you use it for, Lenovo starts to run out of ideas, even suggesting that artists can place items behind it for reference. What's needed is software that can make use of the interaction between screen and reality, something Apple managed on its Vision Pro headset. We don't expect commercial hardware for a while yet. Transparent screens are something we can build now, and both Samsung and LG have demonstrated transparent televisions, which will be commercially available as expensive toys. **–CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

✓ **RASPBERRY PI IS 12**
57 million of them have sold, making it the best-selling computer ever by a wide margin.

✓ **NEW FUSION RECORD**
The Joint European Torus reactor has maintained fusion for five seconds, generating a record 69 megajoules of energy.

✓ **DEEP-SEA DISCOVERIES**
A Chilean expedition using sonar and robot submarines has found four underwater mountains we didn't know exisited.

TRAGEDIES

✗ **PRINTER SPY**
HP's new printer subscription tracks your personal information and what you print.

✗ **CRACKED APPLE**
Reports are emerging that the front glass on Apple's Vision Pro can crack 'without any reason'.

✗ **MISLEADING CHATBOT**
Air Canada has been ordered to honor a refund policy invented by a customer support chatbot, which could cause trouble.

AMD LAUNCHES RADEON RX 7900 GRE

$549 gets you 16GB for gaming

AMD'S RDNA 3 family of graphics cards still isn't complete, as we have another mid-range(ish) offering: the RTX 7900 GRE. It's been available in China since last July—what AMD has done is give the rest of the world a chance to play with one. It'll cost $50 more than the recently released 7800 XT at $549, and aims to offer solid 1440p and reasonable 4K gaming.

At its heart is a cut-down Navi31 GPU with 80 compute units. This places it neatly between the 7800 XT, which has 60, and the 7900 XT, which has 84. We get a healthy 16GB of memory on a 256-bit bus, mirroring the 7900 XT. The clock sits at 1,880Mhz with a top boost to 2,245MHz. What does GRE stand for? Golden Rabbit Edition. It's the original Chinese name, as it was launched in the year of the rabbit. This makes no sense elsewhere, but AMD seems to think it works.

The obvious direct rival is Nvidia's GeForce RTX 4070, which had just dropped to $549, although why anybody still wants one is a mystery, as another $50 gets you a Super with all those extra cores. However, both these cards have 12GB on a 192-bit bus, giving the Radeon an edge. Ray tracing and DLSS are another matter thanks to Nvidia's strengths, but for pure rasterization, the GRE still packs a punch. Radeon's mid-range is starting to look crowded, with three cards within $100, but we shouldn't complain, as we've had to wait long enough for some choices. Nvidia's RTX 4070 has proved popular, looking at its Steam numbers, and the 7900 GRE offers significantly better rasterization performance for your dollars. This looks like a winner—we'll find out more in our review soon. **–CL**

PULSE
PULSE

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INTEL'S BIG BET

CEO says 18A is the "biggest bet we have ever made"

INTEL'S CEO PAT GELSINGER had a big plan in 2021—that the company would produce five process nodes in four years, giving it process leadership. That time is nearly up, with Intel 7 appearing in Alder Lake and then Raptor Lake, and Intel 4 appearing at the end of last year in the processor tiles on the Meteor Lake. Intel 20A has yet to appear, but is due to debut with Arrow Lake later this year. That leaves the final piece, Intel 18A, due next year.

It was an ambitious and risky plan, so risky that Gelsinger has admitted that "this is the biggest bet we have ever made as a company, because it also puts incredible stress on the financials of the company." Yikes, sounds serious, although it seems unlikely. 18A is the process that Gelsinger hopes will make Intel the second biggest customer foundry in the world, usurping Samsung.

Intel has just held its inaugural Foundry Services event, where it revealed that it had signed a deal with Microsoft on a future processor project (our guess is AI) that will use 18A. Intel also raised its estimate for the foundry business earnings from $10 billion to $15 billion, probably not unconnected. It also updated its roadmap, the first significant update since 2021. It introduced the 14A process, due in 2026, and beyond that, Intel 10A for 2027. If these see the light, then Intel will have surpassed TSMC—in process nodes, anyway. It's due to hit 2nm next year, or possibly the year after, with 1.4nm to follow.

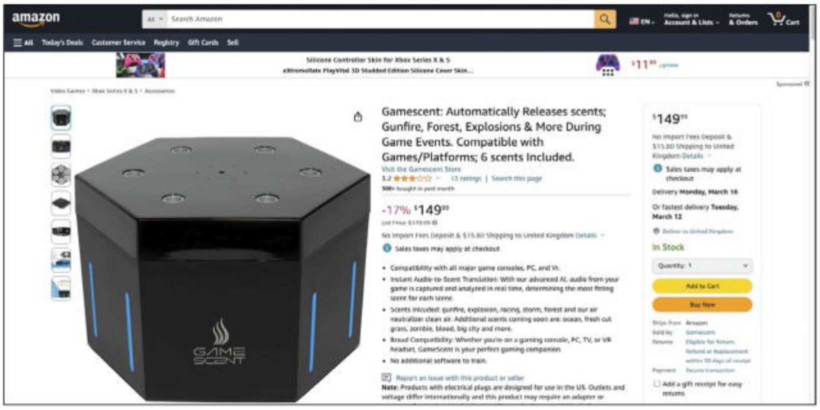
All this magic is thanks to new ASML high-NA lithography machines (165 tons and $380 million each), which have just had what is termed 'first light', proving it is functionally operational, and the optics are working properly. Intel is famously the first customer for these. **–CL**

Smell-O-Game

IF YOU'VE EVER WONDERED whether what was missing from your first-person shooters was the smell of gunfire, then GameScent is here to fix that. As you play, it puffs out an odor. It's basically a fancy essential oil diffuser. The hexagonal box holds six cartridges, five scents, plus what it calls 'clean air', which acts as palate cleanser between smells, of which you have explosion, gunfire, forest, racing cars, and storm. Coming soon will be grass, blood, ocean, and sport arena.

So how does it know what scent to use? Customization for every game would be quite a task, so it's AI to the rescue, analyzing the game (via Wi-Fi) to supply the appropriate scent by tapping the audio feed. It will work on a variety of devices, including consoles, and even televisions.

Smell-O-Rama, in various guises, has been around since experiments in live theater in 1868. Since then, we've had dozens of attempts, none successful, yet the idea won't die. Despite enthusiastic testimonials from Twitch streamers, we have to remain skeptical. The iSmell from 1999 used 128 base odors to mix countless variations. GameScent is stuck with five. To be really effective, you need variety, so this could get old fast. It is currently on Amazon for $150, plus you'll need extra cartridges at some point. These are pretty chunky, and last for 4,000-5,000 sprays, but we've got nothing on their prices yet. First reports from real people say it is technically functional, but scents aren't particularly accurate, or wholesome. **–CL**



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Nvidia's 5090 will be a Beast

Nvidia's Ada Lovelace graphics card lineup is complete. Time to speculate about the next GPU: Blackwell. Sources claim we're due a jump in performance in the region of 70 percent from the top die, the GB102. Reportedly, AMD's RDNA 4 cards will concentrate on the mid-range, with the best chips going into AI. This would leave Nvidia with the market to itself, as the 4090 has. The profits of AI will probably draw the best GB102 chips into its orbit; Nvidia makes six times more from AI than gaming. We'll still get a range-topper, though, complete with GDDR7, PCIe5.0, DisplayPort 2.1, and that performance spike. What it won't be is cheap, with expectations at $2,000. **–CL**

Drop C++ says White House

A report aimed at improving security from the Office of the National Cyber Director has recommended a move away from C and C++. Nearly three quarters of vulnerabilities are due to memory: buffer overflows, leaks, dangling pointers, and general laxity. The NSA has provided a list of memory-safe languages, including C#, Rust, Java, and Python. C dates from what is effectively ancient history for computers, with work starting in 1969. It allows for all sorts of practices that we would shudder at now, such as direct memory access. It'll take a while to switch over, as both are popular, but now it's official policy: devices need software in secure languages. **–CL**

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Jarred Walton

TECH TALK

AMD's RX 7900 GRE goes worldwide

WE SHOULD BE PRETTY MUCH done with new GPU launches from AMD and Nvidia for this generation, barring the possibility of something like a desktop RTX 4050. Both companies have a range of cards priced from around $250 up to $1,600 or more. But with Nvidia's recently released 40-series Super models, AMD didn't look quite as competitive as before.

To remedy the situation, we have the RX 7900 GRE—for Golden Rabbit Edition. The 7900 GRE isn't a new GPU as such; it's built on the same Navi 31 processor as the 7900 XTX and XT, only trimmed down. AMD uses GPU chiplets for Navi 31 and 32, with a larger GCD (graphics compute die) linked to multiple MCDs (memory cache dies). The 7900 XTX uses a GCD with 96 compute units (CUs) and six MCDs, while the 7900 XT has 84 CUs and five MCDs. The 7900 GRE offers 80 CUs and four MCDs. The next step down is the 7800 XT, which moves to the Navi 32 GCD with just 60 CUs and four MCDs.

It's an interesting mix of specifications, and AMD also lowered both the GPU and GDDR6 clocks relative to the other high-end RDNA 3 offerings. That keeps the power requirements relatively low, so that the 7900 GRE basically matches the lesser 7800 XT on power requirements. Ultimately, the 7900 GRE fills the somewhat larger gap between the 7800 XT and 7900 XT with a new product.

Except it's not really 'new'; the 7900 GRE officially launched in July 2023, but it was a China-only SKU at the time. AMD hasn't said why this was the case, but we suspect it was because of the glut of high-end RX 6800/6900 GPUs still in the channel. Nine months later, inventory for most of the previous generation RX 6000-series GPUs has been cleared out, and with Nvidia's $50 price cut on the RTX 4070, AMD needed something more competitive.

The net result is a graphics card that costs about 10 percent more than the 7800 XT while also delivering 10 percent more performance. The next higher GPU in AMD's lineup, the RX 7900 XT, currently starts at around $700. That's 27 percent more than the 7900 GRE, for about 15–20 percent more performance. The law of diminishing returns exists, but the GRE partially bucks that trend.

The 7900 GRE doesn't fundamentally change any of the underlying technologies that AMD has to offer with its RDNA 3 GPUs. As such, it ends up trading blows with Nvidia's price-reduced RTX 4070, usually winning in pure rasterization games, but losing in ray traced games. And while it's AMD's most efficient GPU right now, it can't hope to match Nvidia's best—the 7900 GRE typically uses 60–70 watts more power than the RTX 4070, again for relatively similar performance overall.

Where AMD will go next is the real question. The RDNA 4 architecture should be under way, and we could see the first parts late this year. Nvidia isn't planning to launch consumer Blackwell GPUs until 2025, as far as we can tell, so getting RDNA 4 out first would be a major achievement for AMD. More likely is that we'll see RDNA 4 next year.

Using chiplets for GPUs is a new approach for AMD this generation, and the first CPU chiplets in Zen 2/Ryzen 3000 had some growing pains as well. It wasn't until Zen 3/Ryzen 5000 that AMD's chiplet strategy started firing on all cylinders, and Zen 4 builds on the prior successes. AMD will likely continue using GPU chiplets on its high-end designs. Hopefully we'll see similar generational gains like what happened on the CPU side.

Until then, the 7900 GRE helps flesh out AMD's GPU lineup. It's not the only Golden Rabbit Edition, as AMD revealed RX 6750 GRE last year, with both 10GB and 12GB models. They're basically rebrands of the 6700 10GB and 6750 XT, targeting the Asian market for the Year of the Rabbit, which ended last year. Perhaps we'll start seeing Golden Dragon Editions from AMD for 2024.

The RX 7900 GRE Pulse is a very quiet high-end card, but doesn't radically change AMD's GPU lineup.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.

THE LIST

THE BEST CPUS FOR GAMING

THE OUTRIGHT BEST CPU for you isn't all about raw frame rate metrics—most of us game at resolutions where our graphics card is the dominant player in terms of deciding game performance—so, while AMD is undoubtedly the best for top-end gaming, Intel's chips are superb all-rounders for the money. We're also happy to report that there's a great affordable processor out there right now, too. This list covers off all of the CPUs worth considering in both high-end and budget categories, with our number one pick offering the best price-to-performance overall.

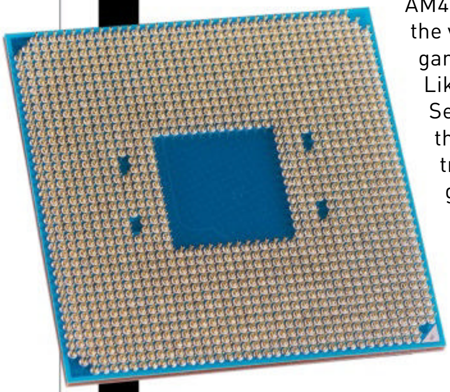
INTEL® CORE™ i9
i9-13900K
SRL4H
V1341690 e4

5 INTEL CORE I9-13900K

Forget about the latest, and arguably fastest Intel chip, the 14900K. The 13900K is a little cheaper, and performs pretty much identically. For pure gaming, the value proposition isn't great here, and AMD's 7800X3D is the obvious pick. But if you're after more of an all-rounder with productivity thrown in, this last-gen Intel chip might just be the best. You get eight monster Performance cores for gaming, plus 16 Efficiency cores to tear through multithreaded workloads. It's quite the combo. **$549, www.intel.com**

4 AMD RYZEN 7 5800X3D

The AMD AM4 motherboard platform has been around since before the dinosaurs, so the chances are that if you have a Ryzen-based PC, it's using AM4. AMD's very latest CPUs use the AM5 socket, so as an upgrade path for AM4 owners, this is it: the very final word in gaming performance. Like its pricier 7000 Series stablemate, the 5800X3D's party trick is 96MB of game-accelerating V-Cache. It doesn't help for tasks like video encoding, but it'll elevate any gaming machine. **$298, www.amd.com**

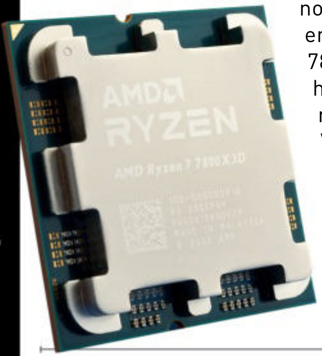


3 INTEL CORE I5-13400F

Intel hasn't brought its newest 14th Gen Raptor Lake Refresh range of CPUs down to this budget level. But that's fine, because the 13400F is already a mighty little chip and gives AMD a very hard time in the budget space in both gaming grunt and multithreading. At this price, Intel's mix of six chunky Performance cores and four efficiency puts the emphasis on the former and that strikes just the right balance for gaming. You really don't need any more CPU than this for gaming. **$204, www.intel.com**

2 AMD RYZEN 7 7800X3D

For pure gaming grunt, this is it. The AMD Ryzen 7 7800X3D is as good as it currently gets. Partly, it's because this is the purer CPU design containing only high performance cores using AMD's excellent Zen 4 architecture. There's no complicated hybrid engineering here, but the 7800X3D's killer blow is a huge 96MB hunk of cache memory thanks to AMD's V-Cache technology. The fact that it's come down in price and now isn't that much pricier than the 13600K just sweetens the deal. **$369, www.amd.com**



1 INTEL CORE I5-13600K

A five-star CPU if ever there was, the 13600K is the best all-rounder bar none. With six beefy Performance cores and eight Efficiency cores, it offers the perfect blend of IPC and multithreaded throughput. Intel may have released a Raptor Lake refresh of these 13th Gen chips, dubbed the 14th Gen, but the performance of the 13600K is more or less identical to the 14600K, and comes in cheaper. Bit of a no-brainer, right? For sure, in gaming terms, the returns definitely diminish, should you choose to spend more. **$298, www.intel.com**

INTEL® CORE™ i5
i5-13600K
SRMBD
L234E621 e4

© INTEL, AMD

Jeremy Laird

TRADE CHAT

Why are graphics drivers so hard?

GRAPHICS DRIVERS ARE HARD. That isn't news. Recently, however, Intel revealed details on its efforts to get its Arc GPUs running really fast. This candor makes me hopeful for its next-gen Battlemage graphics, which could appear this year. The takeaway is that Intel isn't giving up on Arc, and there are reasons to think that Battlemage might just be the bomb.

The difficulty of getting graphics drivers right and more generally optimizing GPU performance is known. At the same time, it's hard not to be a little exasperated with Intel and its Arc graphics cards.

Intel surely knew how tough it was going to be. It's hardly a newbie in the tech space, so surely it put in all the work to do the job before it launched those first Arc graphics cards in 2022? As it turned out, Arc GPUs launched with frame rates all over the place. It did nothing for Arc's reputation, and Intel has been catching up ever since.

The good news is that lots of progress has since been made—performance in any given game is likely to be well optimized. A revisit of Arc performance by YouTube channel GamersNexus found that 12 out of 14 titles delivered performance in line with what you would expect.

That means more often than not, Arc performs well. But exceptions remain, and one in seven games running badly still isn't good enough, not if you want gamers to spend $500-plus on a GPU. So why hasn't Intel just, well, fixed every game?

Unfortunately, it's not that easy. Intel recently gave the example of *GTA 5*, which still benchmarks badly on Arc GPUs. At some settings, it returns frame rates of about half what you might expect based on the A770's performance and ranking in other games. The net result is that it's behind AMD's Radeon RX 6600 and the Nvidia RTX 2060.

It turns out the problem with *GTA 5* is MSAA (multi-sampling anti-aliasing performance). Intel says the issue isn't with MSAA generally, which works fine on Arc in many other games, but its specific implementation in *GTA 5*. Using another anti-aliasing option, such as FXAA, or no AA at all, elevates Arc performance to where it ought to be.

In other words, Intel doesn't just have to do general MSAA optimization. It might also need to do multiple setting-specific optimizations for just one game, on top of getting that particular title or game engine running nicely.

It's not hard to see how that kind of game-by-game, setting-by-setting workload can escalate rapidly, and helps to explain why Arc GPUs struggled at launch and why Intel doesn't just 'fix' everything. There's too much to do.

Intel said the job of reworking its DX9 driver architecture is finished and fully implemented into the driver, hence better performance in most DX9 games, and that they are now finalizing a similar driver architectural rework for DX11, built into a driver update. Intel is now setting its sights on DX12 driver updates in 2024.

That's important not just for existing Arc graphics, but for what it says about Intel's future plans. Rumors have been circulating that Intel might cancel Arc altogether, but the ongoing work going into Arc drivers says otherwise.

It also makes it more likely that the second generation of Arc, codenamed Battlemage, will come out of the blocks with performance closer to its hardware's potential. Recent reports claiming to reveal the specifications of Battlemage suggest that it should be twice as fast or more than the Arc A770 GPU, putting performance in the range of an Nvidia RTX 4070 Ti Super or RTX 4080.

It would be a real tonic for the GPU market to have a new entrant performing at that level, especially as Arc's ray-tracing performance has been comparatively good, something AMD has yet to crack. No doubt Battlemage won't be perfect, but things are looking up for Intel's Arc GPUs.

intel ARC A770
ARC A770
ARC A770 Limited Edition

© INTEL

If its driver optimization work is anything to go on, Intel isn't giving up on its Arc graphics.

Six raw 4K panels for breakfast, laced with extract of x86... Jeremy Laird eats and breathes PC technology.

DOCTOR

THIS MONTH THE DOCTOR TACKLES...

> Deploy new PC
> Office alternatives
> Linux drives

Avoid a reinstall

I was inspired by your Hydra Mini ITX Chassis build (Feb 2024 issue) to go out and spec a similar system to replace my three-year-old setup (also based on one of your builds, namely the AMD Ryzen 9 5950X build from your March 2021 issue). However, having only recently reinstalled Windows 11 from scratch, I'm not looking forward to going through the same process again so soon. Is there any way I can avoid what feels like a colossal waste of time?

—Travis S Gardner

THE DOCTOR RESPONDS: Given your reinstall is relatively new, you'll probably get away with fitting the hard drive to your new PC and simply booting from it. In the Doc's experience, you'll likely encounter several reboots, driver updates, and potentially one or two blue screens of death before things hopefully settle down. You'll also need to run through the activation troubleshooting wizard (Settings > System > Activation) to transfer your digital license, but it's straightforward enough.

The Doc recommends taking a full drive image before you begin using a tool like Hasleo Backup Suite (www.easyuefi.com), so you can roll back if the new hardware fails to take to the installation. If you're a Macrium Home Reflect (www.macrium.com/products/home) user, you can go one step further: take a full backup of your drive, create rescue media, and boot from that after building your new PC. You should see an option marked 'ReDeploy restored image to new hardware' under the Existing Backups tab. Select this, and follow the prompts—for a guide to how it works, visit https://knowledgebase.macrium.com/display/KNOW80 and search for 'redeploy'.

Fix Nginx connection

I found your feature on Podman interesting, but have run into a brick wall trying to get Nginx Proxy Manager to work on my Windows machine. I can get it installed, access it, and set up reverse proxies, but if I try to use it to generate SSL certificates from Lets Encrypt, it consistently fails with an unspecified 'internal error'. It seems to be unable to make the connection—is there a step I've missed?

—Joan D Sampson

THE DOCTOR RESPONDS: It appears that something has changed in a recent update to either Nginx Proxy Manager or the way Lets Encrypt handles certificate requests has led to this error. It has resulted in a string of issues appearing on Nginx Proxy Manager's Github pages with various workarounds being suggested—visit https://github.com/NginxProxyManager/nginx-proxy-manager/issues/3324 for one such example.

The Doc was able to resolve the issue both in WSL and Linux by ensuring that ports 80, 81, and 443 weren't redirected to higher ports (9080, 9081, and 9443 in the original feature). While this is easy enough in Docker, Podman's rootless nature introduces another hurdle: Linux only allows root users to access what it terms 'privileged' ports—all ports below 1,024.

Thankfully, you can override this figure if you're happy to accept the security implications in doing so (in reality, they're unlikely to be an issue for most users). This involves editing the /etc/sysctl.conf file. To do this in Windows 11, right-click Start and choose Terminal (Admin). Type 'podman machine ssh' and hit Enter to access your underlying WSL instance. Now, type:

```
sysctl net.ipv4.ip_
unprivileged_port_start=80
```

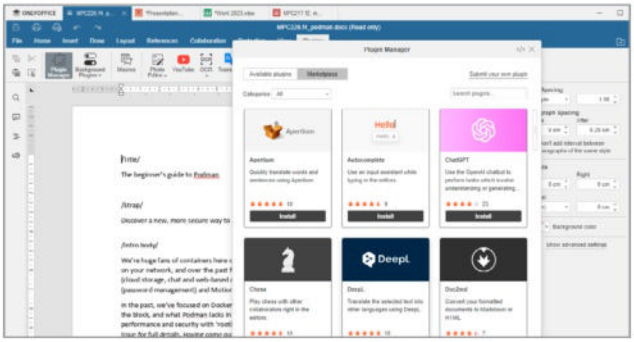
If you now follow the feature to set up Nginx Proxy Manager (skipping the section on mapping ports, as it's now redundant), you should be able to not just access the web interface on port 81 (http://localhost:81 from your PC), but it should also be able to pull certificates from the registry to provide you with secure remote access to those services going forward.

Office alternative

I'm desperate to move away from Microsoft Office, but have failed to settle with the most obvious alternative, LibreOffice. It's okay, but the user interface is too far removed from what I've become used to. I see there are plenty of 'free' Office alternatives out there boasting a more modern user interface, but

↘ submit your questions to: doctor@maximumpc.com many of them appear to be ad-supported or feature-limited unless I pay. Is there a truly free alternative, or must I either put up with an outdated user interface or stick with Office?

—Russell Gilmore



OnlyOffice is a slick—and free—alternative to Office.

© ONLYOFFICE

THE DOCTOR RESPONDS: As you've already installed LibreOffice, I'd recommend you try its tabbed user interface (choose 'View > User Interface', then select Tabbed). This is much closer to what you've been used to in Office, and it may be that simply switching to this is enough to make LibreOffice more usable for you.

If you still can't get on with LibreOffice, or want to try another option, the Doc suggests taking a look at OnlyOffice (www.onlyoffice.com/download-desktop.aspx). It's open-source, and the single-user desktop editor, comprising document, spreadsheet, presentation, PDF editing, and form creation tools, is free to use. OnlyOffice's user interface is certainly closer in looks to Office, although it has fewer features than LibreOffice.

However, there are other reasons to give it a go—first, it's less resource intensive than Office, so feels responsive even on older machines. We also like that it works as a single application rather than being split between separate tools as Word, Excel, and PowerPoint are. OnlyOffice also defaults to opening each document in its own tab within that single window. This behavior can be modified via the program's main settings, but we like the fact that it reduces desktop clutter while making all your documents easily accessible from one location.

It goes without saying that OnlyOffice is compatible with most standard file types, including Office and LibreOffice, but its spreadsheet tool does lack support for some of Office's newer features. On the other hand, a Plugins tab reveals extensions that you won't necessarily find in Office, like a simple photo editor and OCR tool for JPG and PNG files. A plugins store reveals even more features that can be added, from AI helpers to translation tools.

Rounding things off are support for integration into cloud services, mobile apps for editing documents on the go, and the ability to host your own online iteration of OnlyOffice for access through any browser—choose the Community version to get this for free.

Read ext4 drive

A friend has handed me a hard drive and tasked me with pulling off files from it. The problem is, it came from a Linux machine, and after plugging it into my Windows PC, I can't read it. What are my options for accessing the drive? Would a virtual Linux machine be able to do it?

—Peter J Cousins

THE DOCTOR RESPONDS: You'd need live Linux media to be able to read the drive outside of Windows, Peter—virtualization wouldn't cut it. Thankfully, there's an easier option that gives you access from your Windows desktop. Diskinternals offers a free Linux Reader tool (www.diskinternals.com/linux-reader), which is capable of letting you access ext4 drives on a read-only basis to browse their contents and copy any files you need to another drive on your PC.

Once installed, launch the tool, and you should see a window split in three: Volumes, Unallocated space, and Physical drives. Each volume is listed with a drive letter (if applicable) and file system—you're looking for those marked 'Linux ext', which will come from the drive your friend gave you. Double-click the one marked '/' and it should open a File Explorer-like interface from which you can browse the drive and preview selected file types (such as photos). Focus your search on the home folder, where most user files should reside.

Right-click any folders or files you wish to retrieve, and choose Save. Leave 'Save files' selected (the other options aren't available in the free version), and wait for the wizard to count all recoverable files. Pick a folder on another drive to save the contents to, choose options such as preserving the original directory structure, and click Next. Review the files recovered, and click Next again to save them to your chosen drive.

Restore Nextcloud data

I'm moving Nextcloud setups. I want to set up the installation from scratch without having to upload the 90 GB of data from my installation. Is there a way I can move the files to the new Nextcloud data directory, and get the database to recognize that they're there?

—Edward Austin

THE DOCTOR RESPONDS: The files you've uploaded to Nextcloud are stored inside the data directory you configured to point to /var/www/html/data inside the container. Inside this, you'll see a folder named for your chosen username, which contains a further folder—Files—where all your data is stored.

If you were to set up your new Nextcloud instance, manually copy all this data across to the new data/username/files folder, then nothing would show up in Nextcloud itself. That's because the folder isn't actively monitored for changes, but the good news is that you can change this behavior by adding a single line to your config.php file.

The config.php file can be found inside the appdata directory you configured (pointing to /var/www/html inside the container). Navigate to this folder, then enter the config folder inside it before opening config.php in your chosen text editor (say 'nano config.php'). Insert the following line below the line marked 'installed' => true,:

```
'filesystem_check_changes'
=> 1,
```

Save the file and restart the container. Log into your Nextcloud instance's web interface and navigate to your personal files page. You should see the folders are in place, although it can take a while for Nextcloud to analyze them. Once done, you should be able to marry up the folders on your PC to the folders in your new Nextcloud instance using the client app—it'll take a while for Nextcloud to compare the two folders to ensure they're synced, but it's a lot quicker than manually uploading all those files again from your PC to the server.

Once you've synced everything up, delete the 'filesystem_check_changes' line to stop Nextcloud monitoring the folder. ⏻

MAXIMUM FLOW THE 4070 Ti SUPER

The perfect balance of RGB and style

OVER THE LAST FEW ISSUES, we've built a cornucopia of different styles of PC. Whether that's high-end glamorous RGB monsters with enough displays and gifs to make your eyes melt, cooling-challenged ITX towers, or super stealth blacked-out builds featuring the best-value componentry around, all of them have pushed a particular theme in one way or another. They each present their own unique challenge—a way of testing hardware, sure, but equally a way of testing the journalist tasked with building them. That's a big part of what we do, and a key ingredient of learning.

This time around, we decided to do something a little bit different; a little bit more refined. This, dear reader, is our attempt at building a relatively affordable, suave, and sophisticated 4K gaming machine—one that combines the very best in modern-day stylish lighting with some very intriguing and unique hardware to deliver an all-round perfect experience, regardless of whether you're in-game, or rendering 4K content in Da Vinci Resolve.

At its heart, of course, the key selling point for us is seeing how that 4070 Ti Super behaves under different circumstances. At the core of this build lies the 7800X3D CPU from AMD, a fantastic and incredibly popular processor option—complete with Team Red's impressive 3D V-Cache tech—to really leverage frame-rates in-game. Combine that with a beautiful new case from NZXT, and some stunning Light Wings fans from be quiet!, and let's find out just how this kitty purrs, shall we? **–ZAK STOREY**

BENCHMARKS

Part		Price
CPU	AMD Ryzen 7 7800X3D	$369
Motherboard	MSI MAG X670E Tomahawk WiFi ATX AM5	$280
CPU Cooler	NZXT Kraken Elite 360	$268
RAM	32GB (2x16GB) Kingston Fury Beast @ 6000 C36	$135
SSD	2TB Kingston Fury Renegade PCIe 4.0 M.2 SSD	$200
GPU	MSI Ventus 3X OC GeForce RTX 4070 Ti Super	$830
Case	NZXT H6 Flow ATX	$110
PSU	Be Quiet! Dark Power 13 850W 80+ Titanium	$230
120mm Fans	6x be quiet! Light Wings PWM 120mm Fans	$120
140mm Fans	2x be quiet! Light Wings PWM 140mm Fans	$60
Total		**$2,602**

PRICES CORRECT AT THE TIME OF PRINTING

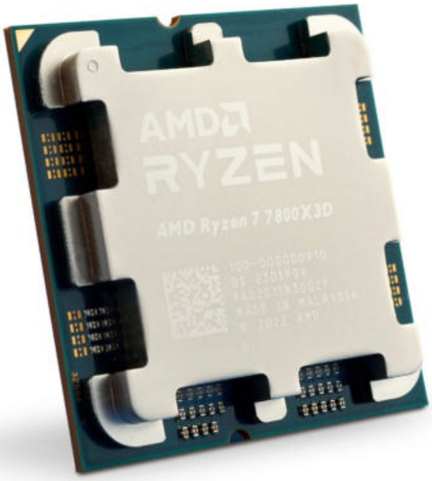
https://content.jwplatform.com/videos/nBgODnqM-u2lN49He.mp4
Please type this URL into your browser if the link is broken

NZXT
25°
Liquid
MAG
DDR5
FURY
GEFORCE
msi
TOMAHAWK
NZXT

BUILD IT!

Step-by-step guide to assembling this PC **PG. 22**

Hardware Heaven



CPU

AMD Ryzen 7 7800X3D

The Ryzen 7 7800X3D is an incredibly interesting processor. At its heart, think of it as a slightly lower-clocked Ryzen 7 7700X. Indeed, it features the same eight cores, the same 16 threads, and the overall chiplet composition is similar, too, with a single core complex providing all of the performance. However, unlike the Ryzen 7 7700X, its maximum clock speed sits at 5 GHz, rather than 5.4 GHz. The reason for this is that AMD has placed a stack of 3D V-Cache on top of the core complex itself.

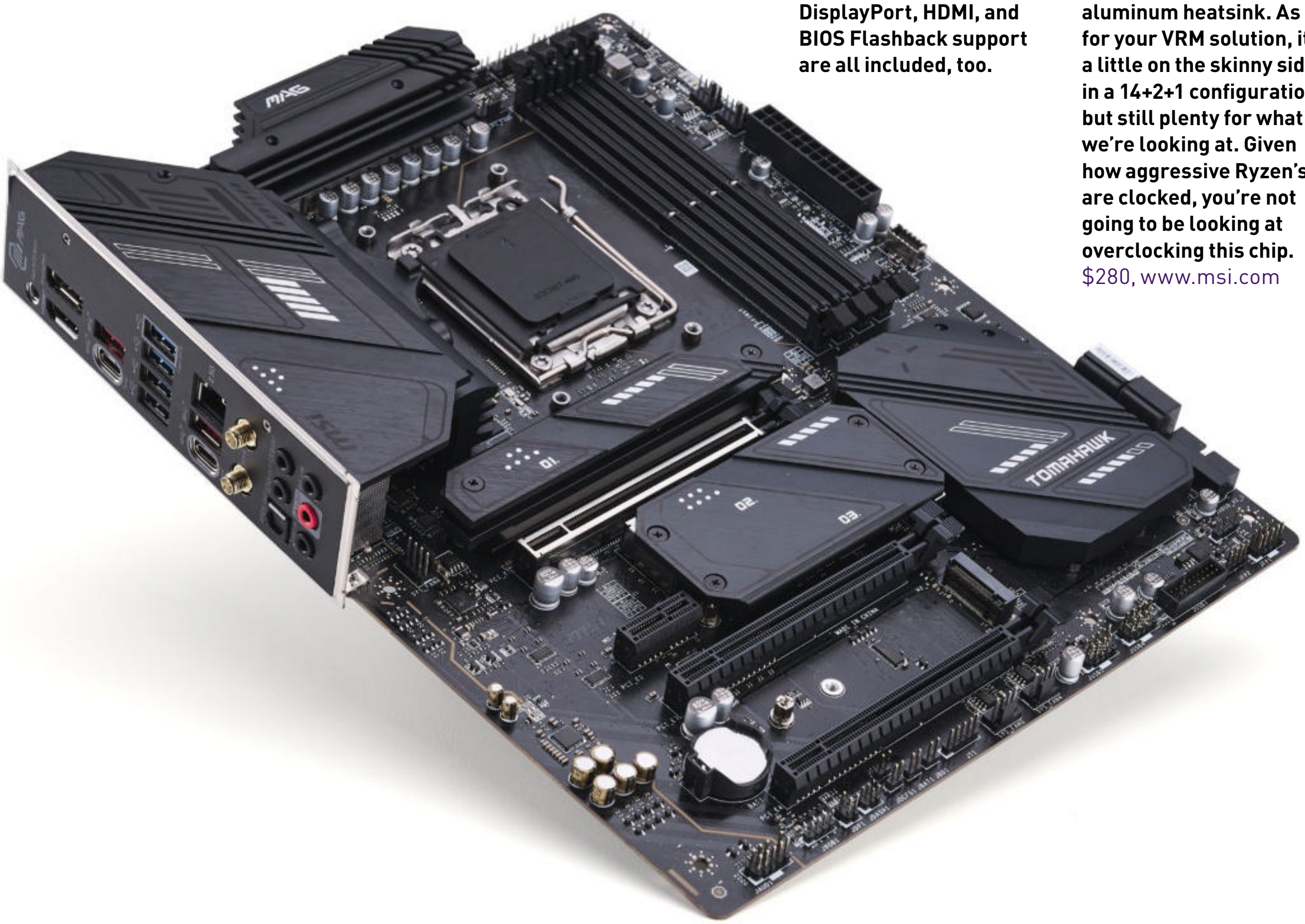
This extra cache gives the 7800X3D access to more super-fast memory for games that prefer it, allowing it to boost frame rates as a result, particularly at lower resolutions. This comes at the cost of extra heat and power-draw (thus the lower clock speed on the core complex the cache sits on top of). It's a smart design, but has had mixed results, as it's predominantly dependent on whether the game in question can take advantage of that extra cache. **$369, www.amd.com**

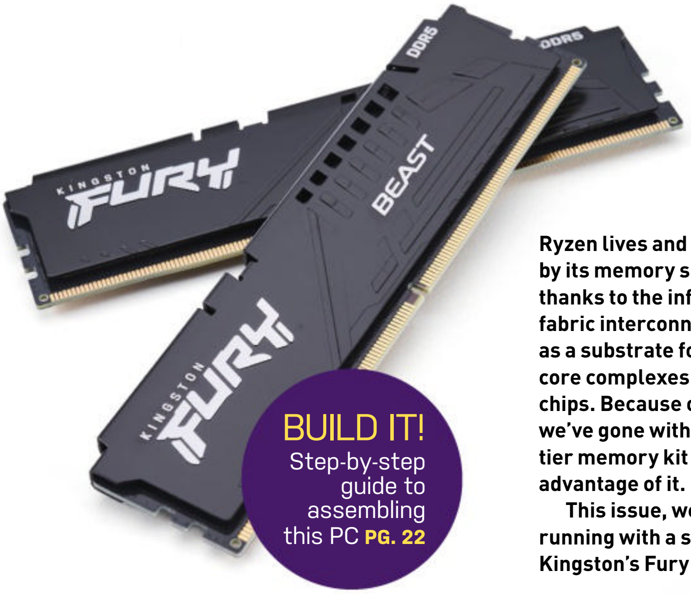
Motherboard

MSI MAG X670E Tomahawk WiFi ATX AM5

For our motherboard, we've gone with MSI's MAG X670E Tomahawk WiFi. This updated X670 board is fairly affordable for an AM5 mobo, coming in at $280. With it, you get access to memory support, PCIe 5.0 for both GPU and M.2 SSDs, and an absolute deluge of rear I/O. Six USB 3.2 Type A, two USB 3.2 Type C, 2.5GbE Ethernet, full 5.1 Audio out, WiFi 6E, DisplayPort, HDMI, and BIOS Flashback support are all included, too.

Onboard connection support is fairly solid, with a decent number of USB 2.0 ports, along with USB 3.X headers and a Type C connector. The topmost M.2 slot also features a chunky aluminum heatsink. As for your VRM solution, it's a little on the skinny side, in a 14+2+1 configuration, but still plenty for what we're looking at. Given how aggressive Ryzen's are clocked, you're not going to be looking at overclocking this chip. $280, www.msi.com





BUILD IT!
Step-by-step guide to assembling this PC **PG. 22**

RAM

32GB (2x16GB) Kingston Fury Beast DDR5 @ 6000 C36

Ryzen lives and dies by its memory speed, thanks to the infinity fabric interconnect acting as a substrate for its core complexes and I/O chips. Because of that, we've gone with a top-tier memory kit to take advantage of it.

This issue, we're running with a set of Kingston's Fury Beast DDR5 @ 6000, with a CAS latency of 36. That gives us a real-world latency of around 12n. Although it's not the fastest kit we've tested, it is one of the most affordable, with 32GB clocking in at $135. Couple that with its low-profile form factor, and it'll happily sit in any build, even a compact one.

Additionally, unlike some other high-performance kits, you can take this over to an Intel or AMD system, enable the respective profile, and it'll work at its advertised speed. You don't need a specific kit per platform, so if you fancy an Intel rig, take these with you, and you'll still be good to go. $135, www.kingston.com

CPU Cooler

NZXT Kraken Elite 360

We're going back to liquid cooling this issue, or at least, an AIO. Noctua's great if you're into air towers, but if you want something with more glamor, then NZXT's Kraken Elite 360 will fit the bill.

The Elite 360 is brand new, complete with a 640x640, 60 hz 2.36" display. That gives us an impressive 383.52 pixel density, making it three times as dense as a 32" 4K display. It also comes with a 2800 RPM pump, plus three F120P static pressure optimized fans as well.

NZXT has also redesigned its cable solution, moving away from dual USB and proprietary connectors, to a single cable solution that provides power, LCD USB connectivity, and a pump fan cable all in one. You can get this in an RGB variant for a little extra, but as we're dropping the fans in favor of some other units, that's not an issue on this build. **$368, www.nzxt.com**

Hardware Heaven, con't

SSD

2TB Kingston Fury Renegade M.2 PCIe 4.0

PCIe 4.0 NVMe M.2
KINGSTON FURY
RENEGADE

Another Kingston pick, our SSD for this build is none other than the Fury Renegade PCIe 4.0 SSD. This is by far one of the most impressive PCIe 4.0 drives we've tested, even beating the Crucial T500 in a number of our real-world tests (in fact, it actually beats some PCIe 5.0 drives we've used, too, but more on that another time).

Initially designed for use in the PlayStation 5 as expandable storage, the Fury Renegade absolutely dominates in both sequential and real-world performance. It utilizes a curious mix of 176-layer TLC from Micron, alongside a Phison E18 controller, but the more impressive addition is a full-sized DDR4 chip acting as a cache, which really helps accelerate speeds. **$200, www.kingston.com**

BUILD IT!
Step-by-step guide to assembling this PC **PG. 22**

GPU

MSI Ventus 3X OC GeForce RTX 4070 Ti Super

The second of Nvidia's Super launches, the RTX 4070 Ti Super is an interesting proposition compared to the other two Supers.

In truth, it's bit of an oddity—the RTX 4070 Super managed to get a 20 percent bump in overall internal GPU hardware (CUDA cores, RT Core, Tensor Cores), but not in memory, and a similar price. The RTX 4080 Super, got a five percent bump in hardware, but (technically) received a $200 price drop on its RRP. The RTX 4070 Ti Super sits somewhere in the middle, receiving a 10 percent internal hardware bump, along with 4GB of extra VRAM (from 12 to 16GB), and an identical price.

Odd improvements aside, we've gone for MSI's AIB variant here (there's no Founder's Editions available), which comes with a fairly chunky triple cooler, and some slightly improved performance figures (post-launch).

On average, we're seeing 4K frame rates in the 70s and 80s, making that $830 price tag a little easier to swallow. Although it's not as good a value proposition as the 4070 Super, it should have a somewhat longer lifespan than its little brother.
$830, www.msi.com

GEFORCE RTX
msi
msi
msi
msi

be quiet!
LIGHT WINGS
120mm PWM high-speed
LIGHT WINGS
140mm PWM high-speed

Fans

be quiet! Light Wings PWM 120/140mm Fans

Another be quiet! pick, we've gone for a whole arrangement of Light Wings fans in this build. These crisp, subtle numbers pack a punch when it comes to performance figures.

You can buy them in two colorways (black or white) and two variants (high-speed or stock). We've gone for the stock wings to keep noise to a minimum. At full tilt, the 120mm variants register 20.6 dB(A) with 41.51 CFM and 1.66 mmH2O, meaning they're not entirely static pressure optimized, although we're not too worried, given the number of them we have in this build. The plan is to install three intakes in the side, two 140mm intakes in the floor, and three 120mm exhausts up top. Not only will that lead to a positive pressure system minimizing dust, it'll encourage the H6 Flow to act as a chimney and dissipate heat faster.

For reference, the high-speed variants top out at 31 dB(A), and produce 52.3 CFM and 2.6 mmH2O respectively.

$180, www.bequiet.com

PSU

be quiet! Dark Power 13 850W 80+ Titanium

It's a familiar face from last issue, but we've decided to run with be quiet!'s Dark Power 13 once more. It's still a top-tier pick, although the price bump is slightly annoying, as it's gone from $190 to $230—probably a more reasonable price, given it's 850W ATX 3.0 certified and comes with a direct 12VHPWR cable. If you want to get custom-sleeved cables, be quiet! will sell you those, too.

$230, www.bequiet.com

be quiet!
DARK POWER 13

Case

NZXT H6 Flow ATX

Another new fishbowl case has landed, this time from NZXT. The H6 Flow has an impressively small footprint paired with some serious cooling potential, plus plenty of cable management, all in an ATX form factor with a unique angular design.

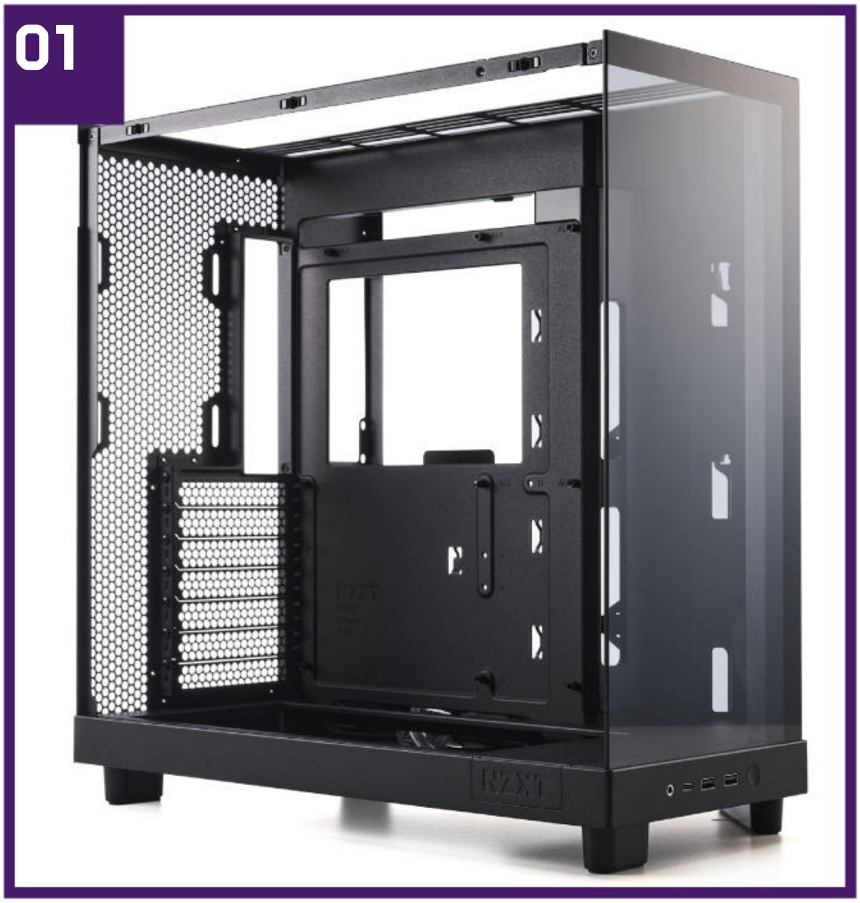
There's support for nine fans in the chassis, two 140mms in the floor, three 120mms in the side and roof, and one 120mm in the rear. On top of that, it comes with plenty of cable management grommets and cables, two USB Type As, and one USB Type C.

It's that angular front intake that's most impressive—having that angle ensures the front fans will still have solid air intake access. It comes with three intake fans, and you can pick one up in black or white, or in RGB variants.

$110, www.nzxt.com

Go With The Flow

LENGTH OF TIME: **2 HOURS**
LEVEL OF DIFFICULTY: **MEDIUM**



01

SO, THE HARDWARE has been selected—a fairly stock-standard mid-tower ATX build. There won't be a lot to write about, then? Not quite—there are still some decisions to be made that are open to personal style. At its core, the most crucial element, aside from figuring out whether the 4070 Ti Super plays as well with the 7800X3D as it does with the 14900K, is that chassis. It is phenomenally cheap for what you get, almost to the point of being better value than the Corsair 4000D Airflow, our go-to chassis for blueprints for an age. It's nice because not only does it not compromise on the cooling front, but it manages to do that without necessarily costing the earth, or swerving away from the modern style of chassis that we've all come to know and love .

It's the one key component that we'd actually suggest remains the same in this build, regardless of what else you'd change. For instance, you could opt for an Intel Core i5-14600K instead, or a Ryzen 7 7700X if you want a bit more multi-core goodness. Alternatively, you could drop down to an RTX 4070 Super, or change up the storage to something slightly more affordable. There are numerous options you could choose, but it's challenging to find a better-value proposition than that thing right now.

Speaking of tweaks, one area we'd suggest you do consider is that CPU/GPU combo we mentioned earlier. Super cards are seriously pricey right now, certainly when you're not buying direct from Nvidia. If we're honest, the 4070 Ti Super is a solid unit, but still falls short of the value proposition that the 4070 Super represents. One other point about the H6 Flow to bear in mind is that this is quite a short case. It'll only support graphics cards up to 365mm in length, so any number of 4080 cards might struggle to fit in this one.

CHASSIS SHENANIGANS

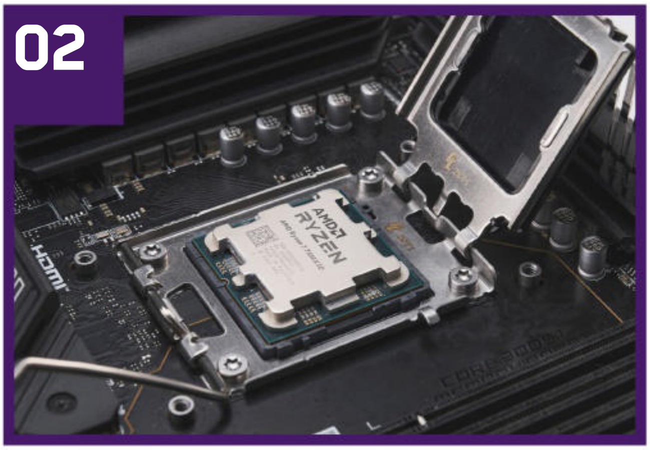
Bet you can guess what's coming. Yep, it's our favorite time of the build, the chassis teardown. We should probably ask Ifixit to sponsor this step. Yep, it's in every build log we do, and with good reason. Not only does it reduce the weight of the chassis and protect the panels of your pristine, shiny new case, but it also gives you a lot more wiggle room to work with.

These fishbowl cases are unique in their design, however. For example, NZXT's H6 Flow actually relies on that front window to provide structural integrity to the entire frame of the unit. By the looks of it, you can actually remove the panel if needed, but we'd advise against it, unless you intend on spraying or modding the thing. That aside, the bulk of the panels can be removed fairly easily. Both the rear side panel and glass window have a single thumb-screw securing them in place. The roof simply pops off underneath your hand, and that angular side intake can be removed by pulling from the top as well (although you'll need to remove the roof cover first). Once done, you should have a very bare-bones case that looks like this [Image 01]. We've gone one step further and removed the front intake fans here as well.

Given our penchant for aftermarket fans, we generally tend to remove all of the stock-included fans anyway, but it's worth noting that they're all well routed and cable-managed into the back of the chassis, if you do want to keep the stock ones in there.

FIRE THE PHOTOGRAPHER (JUST KIDDING)

This journalist should have paid more attention. If you cast your eyes to [Image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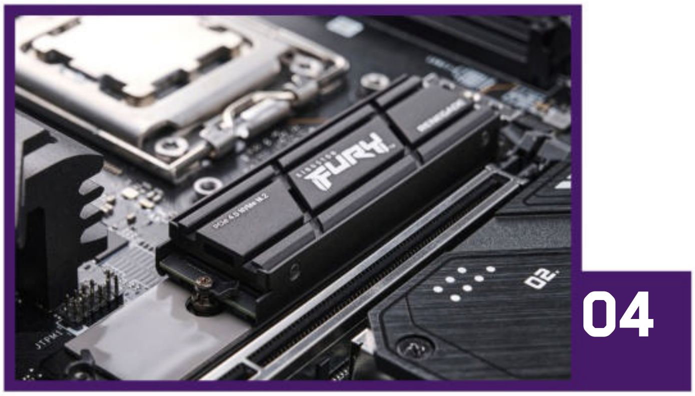
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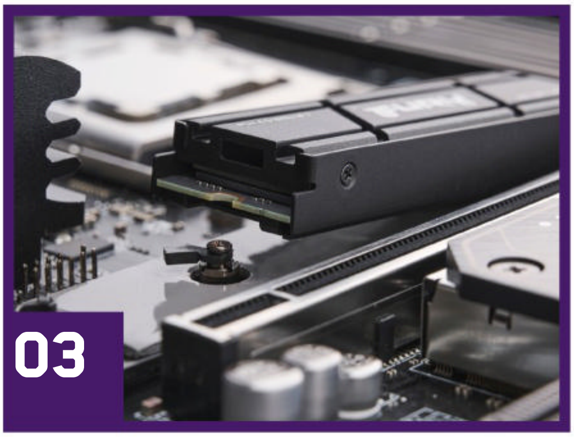
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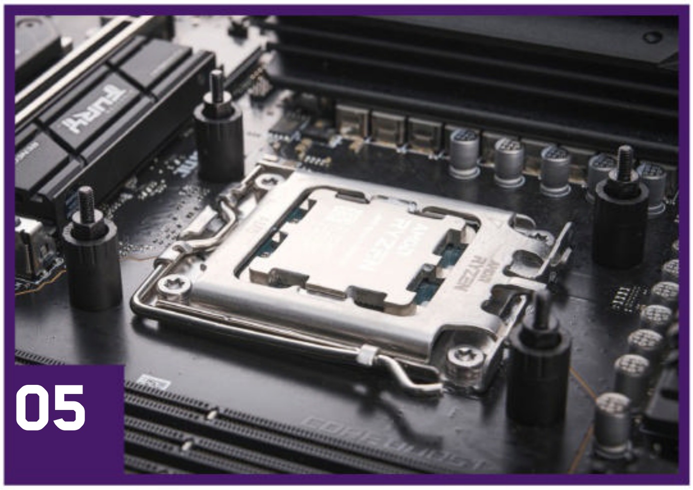
05

02], you'll notice a very nice, clean, close-up shot of the installation process behind the Ryzen 7 7800X3D. Now, we specifically asked for the motherboard box the mobo was sat on to be included in this shot. Clearly it hasn't been. All fool on us for not double-checking, but for your reference, it's always worth preparing your motherboard on top of the product box itself, as it acts as a fantastic anti-static temporary workbench. Just remember not to put it on the outside of the antistatic bag on top of the box, because that, er, conducts static.

Anyway, with the motherboard suitably situated on its supportive box, to install the AMD Ryzen 7 7800X, simply lift up the retention arm on the LGA socket, carefully lift up the bracket, then place your CPU into position, making sure it aligns fully with the notches in the socket. If you're ever in any doubt about the correct orientation, remember that the writing reads from left to right, and installs from the top left of the motherboard itself, as it sits in the case. Once you've gently placed your CPU into position, lower the bracket back down, and replace the retention arm so that the little u-bend clips onto the bracket and secures the CPU into position.

M.2 WOES

With our CPU in place, next on the agenda is Kingston's Fury Renegade M.2 PCIe 4.0 SSD. It's a hefty SSD, with a chunky heatsink and plenty of capacity on board. Initially designed for expanding the PlayStation 5's storage, it works equally well (if not better, if we're honest) as an SSD for your PC. As you can see from [**Image 03**], however, we did have a few issues with it. For a start, we really wanted to keep the included heatsink, but unfortunately, that extra plating around the SSD increased the overall height of the drive to the point that MSI's rotating security clip couldn't effectively secure it in place.

Now, as you can probably spot from that image, it is entirely possible to remove the heatsink from the SSD and run it solo. Alternatively, you could—and probably should—just buy the non-heatsinked variant for use in a PC. However, we were feeling stubborn.

After a few minutes of searching the motherboard box to see if there were any additional M.2 screws we could use to secure the drive, we came up with a somewhat unconventional solution. The logic was simple: if there was an M.2 screw in the motherboard box, it had likely gone missing on the review sample's travels, but that would mean that you could remove the clip anyway. So if we unscrewed the M.2 latch, placed the drive in position, and then resecured the latch back down afterward, we would effectively lock the renegade into place, eliminating the problem. Thus, [**Image 04**] was born.

RELEASE THE KRAKEN…

…(sorry). With the CPU and SSD installed, it was time to move on to preparing the motherboard for the CPU cooler, namely installing the standoffs. With the new NZXT kits, you actually get reversible plastic spacers, along with a set of screws. We say 'reversible' because if you're running AM4, you place the tapered ends that you can see in [**Image 05**] down, and if you're using AM5, like we are, you place them facing up, then secure them in position using the included standoff mounts, which is pretty neat. We're missing a step here, however, and that's the AM4/5 brackets.

As standard, each AMD motherboard comes with pre-attached brackets for AMD's own Stealth and Wraith CPU

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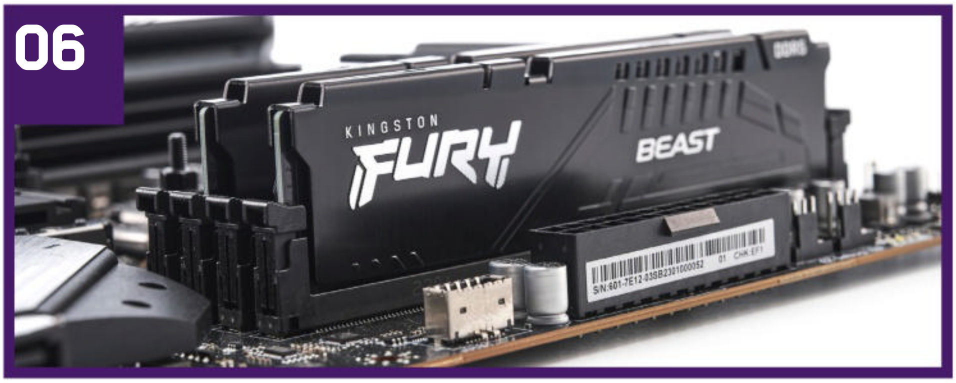

08

07

MAG
HDMI
FURY

coolers. Some AIO partners also still use them to attach their CPU coolers. The plastic brackets fit directly onto a removable backplate on the motherboard themselves. Remove the screws holding the brackets in place, and what you're left with is a CPU cooler bracket, perfectly aligned so that you can use it to mount your CPU cooler hardware from a third party. It's a neat addition, and a step up from what you get with Intel boards and hardware. Also worth noting is that this is the most impressively secure CPU cooler-mounting solution we've seen outside of a liquid-cooled waterblock, so good work, NZXT.

LOW-PROFILE SLEEKNESS

There's that photographer again, moving the motherboard onto the white tabletop. Curses. Joking aside, installing our Kingston memory is super easy. Lift the notches up on the top of the two slots you want to install your DRAM into, line up the sticks, making sure the notches on the slot and the DIMM match, then carefully push them into position. This may require a fair amount of force—just make sure you're lined up, and you hear the click of both latches [**Image 06**].

It's also worth checking the sides to ensure that all your pins and contacts are fully installed. There's nothing worse than building a system like this, going all the way through the build process, then getting to the end, and the system boot looping because your memory isn't installed correctly. At this point, you'll have to go through the tedium of diagnosing and troubleshooting every component to figure out what has gone wrong (it's almost always memory).

With the mobo now prepped, and because we've ran out of ideas for pithy subheadings to do with motherboards, it's time to get this bad boy into the PC [**Image 07**]. This step's an easy one: lay the H6 Flow down on its side, grab the included box of goodies and accessories NZXT has hidden away in the hard-drive caddy, and grab the screws for the motherboard standoffs. Then, carefully place your motherboard into position. There's a slightly taller standoff point that sits in the middle of the ATX form factor—you can just about see it in the bottom-left of the leftmost DRAM stick. This helps with positioning the board. Once in place and resting correctly above the standoffs, secure it down with the screws.

Always make sure you use as many screws as you can here, as it's important that your motherboard is grounded correctly on the case itself to help with any static discharge. We have had it in the past where some of our colleagues in other brands haven't used enough screws, and their PC is shorting out due to incorrect installation of the motherboard.

LET'S DO THE FANDANGO

Now, things get a little tricky. Where do you go from here with a build like this? Well, given the space limitations we have, it felt natural to go with fan installation next. The H6 Flow has a cutout in its base for two 140mm fans, plus a cable passthrough to allow you to run the fan cables straight to the back of the case, without interfering with any of the motherboard's space. Pretty neat. We grabbed our 140mm fans, lined them up so the cables were pointing to the rear of the case, threaded those cables through the passthrough, and then secured them in place, using the included fan screws that come with the fans themselves. You do have to turn the chassis on its side to access the mounting location, but it's not too much trouble.

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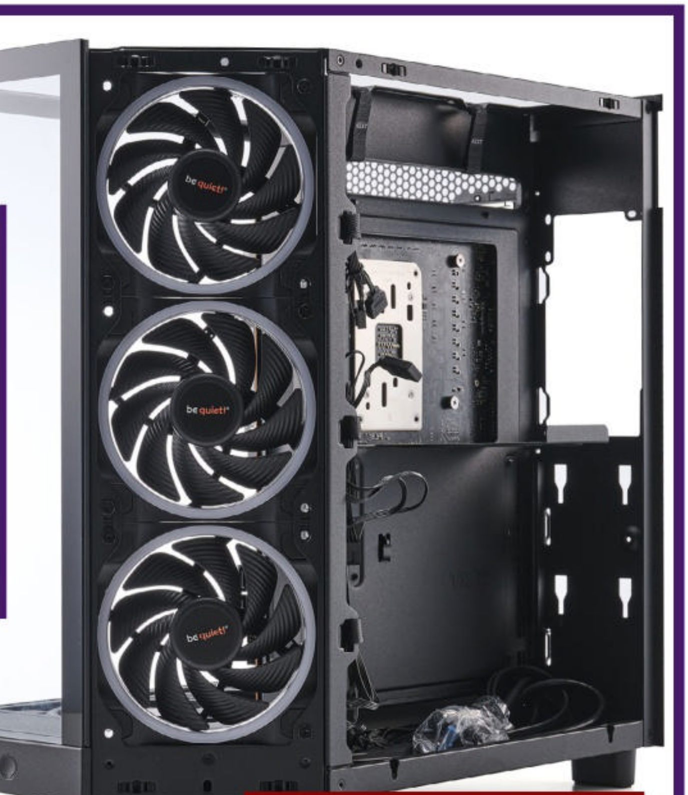

One thing we will say is that there's not a huge amount of wiggle room when it comes to fitting these things, as they sit very flush in the cutouts, so weaving the cables through the passthrough and pulling them out first helps a lot. Also, as a minor point of annoyance, there's no dust filter down here, which seems like a misstep, given it's an intake sitting low to the ground. You do get this drilled-out finish [**Image 08**] here, but that's also kind of annoying, as there's no way of removing it, and these types of perforations typically lead to poor fan performance by introducing turbulence. We will admit that this is mildly ironic, because on the one hand we want there to be a dust filter to stop dust, but mostly because we want to remove it to improve performance. The user should have the option to do that if they so desire, or leave it in place to catch dust, rather than the perforations that the H6 Flow currently has instead. It's effectively the worst of both worlds.

TIME TO MAKE SPACE

There was a hard drive caddy tight here [**Image 09**], but we removed it. There's a thumbscrew that holds it in place that secures it on the rear of the chassis—remove that, then lift the caddy up and out. It's great if you've got a 3.5 or 2.5-inch drive, but we've got bigger plans for this area. It's effectively going to be our personal fan hub center, as we've got eight of them, each with a PWM fan header, plus an RGB connector to deal with as well. That's 16 cables to manage in total.

With that sorted, it was time to get those side intake fans in. This is another area of the case that was incredibly tight to work in. Let's be clear here—there's no way you can get a 360mm radiator into this space. Even getting the three 120mm fans in was a challenge, not only because you've got fan cables to route out to the right there [**Image 10**], but also because there's such a limited amount of space, and there's no room for the reservoir you'll find on the top of a 360mm radiator. We got all three fans installed, but it was a tight squeeze that required a bit of wiggling to get everything in position.

With the bulk of the fans in place, next on the list was the CPU cooler and top-mounted fans. However, a cursory glance to the top of the chassis suggested that spacing here, and working around them once it was installed was going to be, well, challenging. So with that in

BEHIND THE FANS

You might notice that when it comes to fan installation, we typically only use two screws per fan across the vast majority of our builds, in a diagonal position. We do this predominantly to minimize tear-down time. Once a system is built, photographed, and benchmarked, it's typically torn back down and the parts returned to storage, or to their relevant manufacturer. To that end, we typically only install two screws per fan.

Once upon a time, installing fans using only two screws would have left clearance space on certain corners, and allowed for inefficient airflow. However, since modern fans have come such a long way, and the shrouds are now so advanced, usually featuring rubber grommets, this is no longer the case—two screws is more than enough to secure the fan in place.

For your own personal systems, we highly recommend utilizing all four fan screws, as it will keep the fan in position for longer. If you do need to transport your PC or ship it anywhere, it will be far more secure than if those extra screws weren't there.

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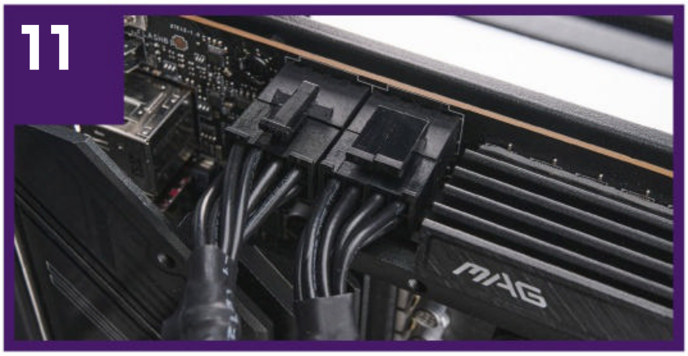

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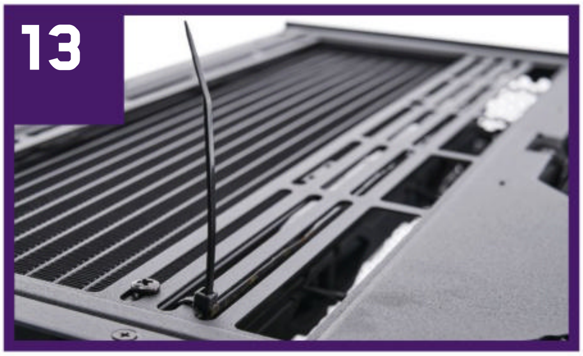

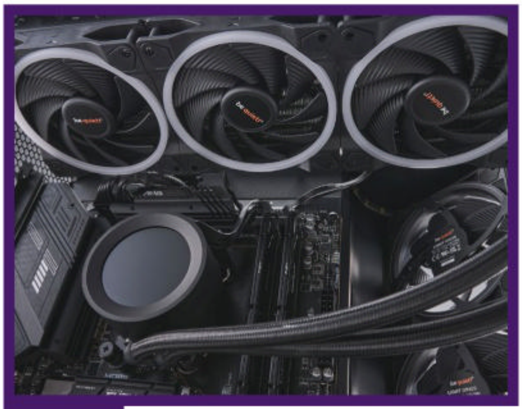

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mind, we decided to take an alternate route and pre-route some of the more challenging cables. Anyone who's built any amount of PCs will tell you that CPU power cables are a nuisance to install. They're clumsy and awkward, and at the top left of the chassis always cause pain to the installer when trying to plug them in. Because of that, we removed them from the power supply (still plugged in from the last build after we'd removed it from the chassis), installed them directly into the motherboard, then threaded them through the top of the case and used the cable routing channels to ensure that it would be an easy task to manage later down the line [**Image 11**]. With that out of the way, all that's left to install up there is the pump fan cable.

THE TWISTS AND TURNS OF PUMP HEADS

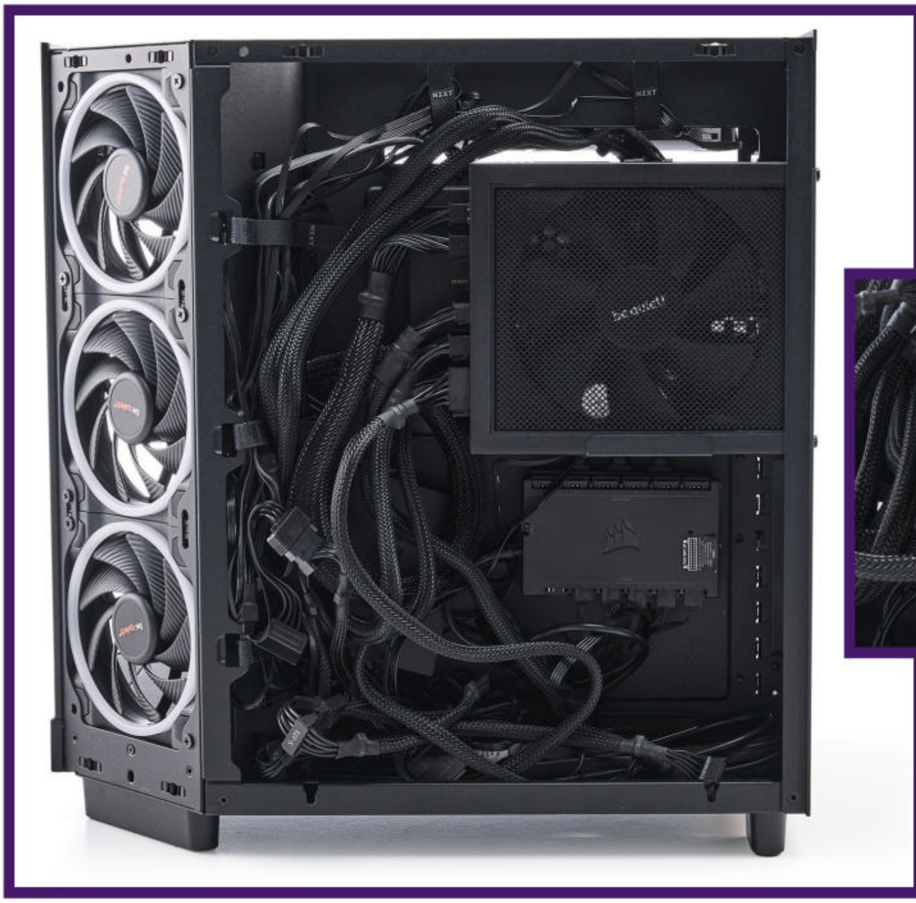
With the CPU cables now pre-routed, it's time to turn to our CPU cooler. As standard, you'll need to remove the Intel bracket from the pump block itself and replace it with the AMD one. To do that, simply push the bracket up, rotate it, remove it from the block, and replace it with the AMD bracket instead. It's a super-quick and simple process, and gives you some flexibility. You'll notice in our shot [**Image 12**] that our tubing is actually placed at the bottom of the block itself. We decided to go down this route to keep our cables routing up and out of the block itself. Theoretically, you can rotate that bracket any way you like, so it'll allow you to run the cables in any orientation. NZXT's CAM software will also allow you to rotate the display too, but bear in mind that it only tolerates 90-degree increments. Still, that does give us a bit more flexibility with cable routing.

Moving on, and because we're a sucker for a bit of glamor, we're turning to that cheap 24-inch magnetic white LED strip for some internal lighting again. This time, we've carefully moved it to the top of the chassis and hidden it behind the radiator, running along the top of the case. This way, it'll throw light down into the case, and really make that hardware pop when the system is turned on. It's a bit finicky to do this, as the strip is laying flat on the top of the case behind the bracket [**Image 13**], and then curves around to the right, performing a 90-degree twist as it does so. To encourage that strip to stay in position, we've used a cable tie to support it at the top of the chassis. This should make things a little easier.

It's powered by a SATA power connection that connects to it via a 4-pin RGB header. We've run that cable through the same cable grommet that the top fan's cables occupy as well. This did require removing the fan temporarily, running the extra cable through there, then resecuring the fan, but it's a small price to pay for extra illumination.

FINAL TOUCHES

With all our fans installed, the GPU is up next. At this point, we've gone ahead and pre-routed the rest of the power supply cables we need as well, running the 12VHPWR cable from where the GPU will be through the bottom of the case, and pre-installing the 24-pin ATX power as well. On top of that, you may spot the two USB headers in place, ready for the fan controllers we're utilizing, along with the front panel connector. These are all located on the bottom right of the motherboard. We've not bothered about installing the HD audio passthrough, however, as these typically perform poorly. When installing audio devices or anything of that ilk, USB or otherwise,



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always use the rear I/O ports instead, as it reduces the opportunity for unnecessary electrical noise to intercept the signal at any point.

With that out the way, it was simply a case of installing the GPU, removing the PCIe slot covers from the H6 Flow, placing the chassis on its side, and sliding the GPU into position in the top-most PCIe slot, before resecuring it back down and installing the power cable. Nice and easy [**Image 14**]. One decent element of the 4070 Ti Super and its younger brother is that they're not built like a concrete block, so they're much easier to handle, mount traditionally, and fit inside smaller cases like this one.

WELCOME TO CABLE MANAGEMENT HELL

Now the fun begins, namely the cable management, and oh boy was it a doozie. To explain this fully, the NZXT Kraken Elite 360 has four cables that you need to install: one a USB header, the second a SATA power, the third a fan splitter for the three fans you attach to the rad, and finally a fan connection for the pump. Then, you've got each Lightwings fan, which each technically have three cables per fan: one, the PWM connection, the second a dRGB connection, and third a dRGB passthrough (so you can theoretically daisy-chain them together). On top of that, we've got the SATA power required for the LED light strip, along with the two dRGB cables for the be quiet! RGB controllers, plus SATA power for both of those, and of course, to control all the excess fans not plugged into the NZXT Kraken, we've grabbed that Commander Core again, which requires a USB and SATA power, too.

So to clarify, the cooling solution total has 34 separate cables that need routing or dealing with. This then gets bumped up to 35 with the LED light strip. This really does give you an appreciation for those smart daisy-chaining systems. Yeah, they might be slightly more annoying to wrap your head around, but it's a heck of a lot easier to manage.

To that end, you can probably start to understand why [**Image 15**] looks the way it does. We've mounted the power supply in the top with all the SATA power and cables installed, then tried to route those cables as best as we can using the velcro strips wherever possible. On top of that, we've not installed the HD Audio Passthrough or the front-panel USB headers—you can do that if you want, but we generally don't use them, so tucked away they go. Also, you could theoretically daisy-chain a bunch of those fans together and then connect groups of them to the RGB controller that be quiet! includes, but given that there are voltage limits on doing that, and you'd lose out on individual control, that's just not a path we're keen to go down.

As for the fan controllers, we've stacked them together with some double-sided 3M tape that be quiet! includes with the triple pack controllers—one's sitting behind the Commander Core here [**Image 16**], and the other is hanging loose to the left. When you do get around to cable-managing setups like this, it's always best to break them off into groups. Get all the cables from the top three fans, tie them together with a bit of string, and leave them on top of the chassis. Do the same for the three intakes on the left and the two in the bottom, then separate out the CPU cooler's cable. This helps to visualize which cables are for what fans, and where you can run them from a cable management perspective. With that done, our build is finally complete.

Smooth sailing

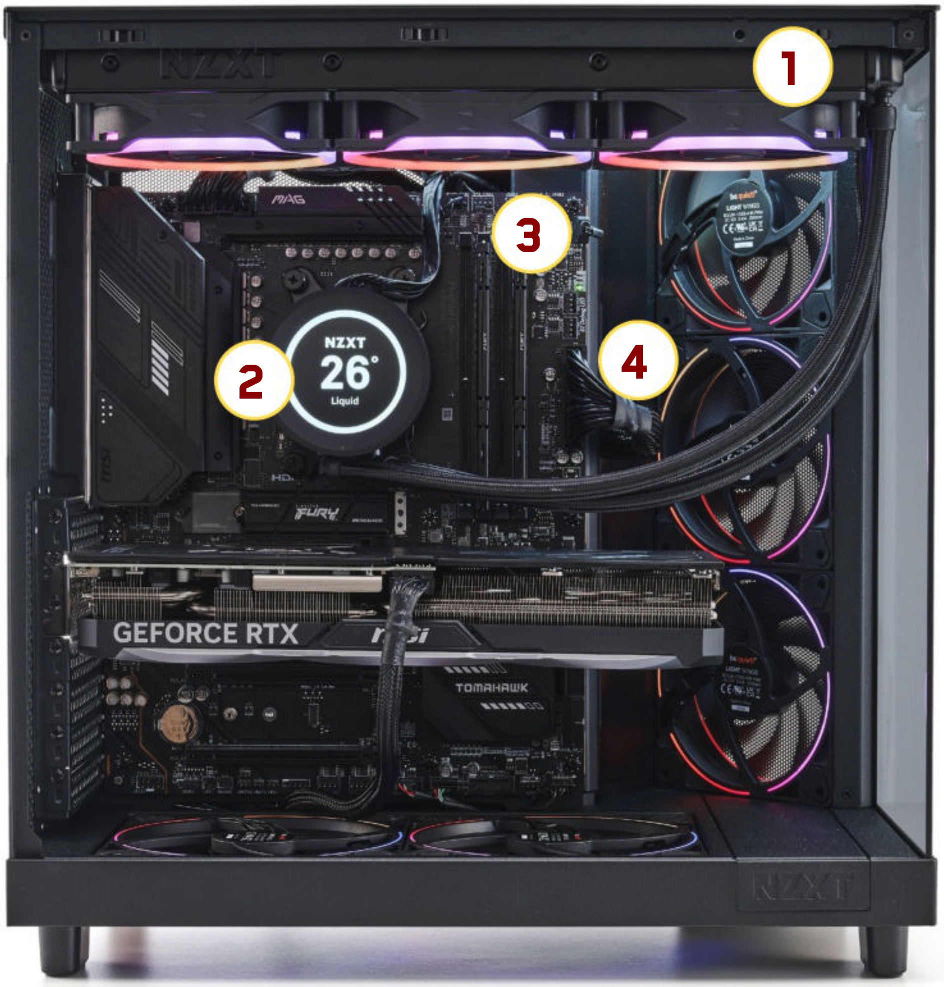
SO THEN, cable management aside, what was it like to build this beauty? Honestly, it was a fairly simple process. The biggest issues we faced mostly revolved around those cable management considerations. The H6 Flow is an incredibly well-designed chassis, but its commitment to form factor does tend to lead it somewhat astray when it comes to clearance in some areas. Take the bottommost 140mm intake fans and those side 120mm intakes, both of which are insanely tight, space-wise. It looks fantastic when finished, but getting the fans in there and the cables routed correctly took time, was finicky, and can be a little frustrating.

The same goes for the top of the case as well, just above the motherboard tray. One glance at that during the build process immediately gave us pause, knowing that if we didn't act before installing the CPU cooler, we'd be in for a bad time trying to get those CPU power cables in. Yes, you could theoretically try to wedge them in with the use of a screwdriver, lacerate your fingers pushing them in, or mount the fans after the fact, but if it's something that we can avoid from the get-go, then we're definitely taking that option.

That's a thing that we've always tried to push here at *Maximum PC*. If anyone ever tells you that there's an absolutely correct do-or-die order to building a PC, just ignore them. You need to be fluid in your approach—if something looks out of whack, or like it's going to give you clearance ahead of time, it probably will, and you need to act accordingly. Moore's law might be the go-to reference in the world of PCs, but honestly, when it comes to building them, Murphy's law holds far more weight. If you assume that every facet of your build could be an issue, then you will never be caught off guard by it.

Philosophical building tips aside, the PC itself looks absolutely stellar. We had concerns about those floor intakes being a bit muted due to the LED rings facing the wrong way, but the rear of the Light Wings also have a fine thin RGB outline on them that looks absolutely incredible. Speaking of lighting, our ancient 24-inch light strip still punches hard too, and really does help illuminate that interior. However, it's one of the few things we'd change. You can't see it in the photography (our art and photography team are remarkably skilled at their jobs), but as we've coiled it around the internal wall there, if you're facing this PC at the wrong angle, you do get blinded by it as it shines in your face. Going for a shorter 12-inch strip would reduce the need to curve around, and hide the light strip better.

But otherwise, the challenge, to build a clean-looking and refined PC, with just enough RGB and some potent hardware at the same time, seems to have been a success. What do you reckon?



1 You can't see it here, but just above the topmost radiator is our 24-inch LED strip. A really nice upgrade to this would be to move to a 12-inch strip instead.

2 The CPU pump block looks great here, but if we'd rotated the bracket so that uppermost cable was coming out on the left side instead, we could potentially route it through the gap between the rear I/O and VRM, near the power, which would look cleaner.

3 Unironically, a nice RGB DDR5 RAM kit here would look incredible, and this build could probably use it.

4 We're starting to sound like an old record here, but a custom black cable kit—or a white one, for that matter—would really make our components pop, and take this build to the next level.

Take the power back

WE LOVE a confusing set of numbers here at *Maximum PC*, and oh boy, do we have some below. Performance across the board for our build was generally pretty good—the main highlights were *Total War: Three Kingdoms* finally reaching above that 60 fps mark, and *Metro Exodus* rolling across the finish line with a smooth average frame rate of 54 fps. Jump over to the synthetic CPU-oriented benchmarks, however, and they tell a very different story. That single core performance in particular is quite the shocker, at 1,801. We did a few extra runs to be sure, and even double-checked everything, from the CPU cooler to memory settings being enabled correctly, and nope, that's the best out of all four runs we committed to.

Why so low then, compared to the 7600X? Well, we can only chalk it up to either something being askew with the BIOS compared to the Gigabyte board, or more likely a result of the significantly lower clock-speed and increased 3D V-Cache on the 7800X3D. The 7600X in our zero-point actually has a maximum boost clock that reaches up to 5.3 GHz, while the 7800X3D tops out at 5.0 GHz. This doesn't sound like much, but over a 10-minute Cinebench run, those numbers add up quickly, leading to such a massive delta there. Unsurprisingly however, given the 7800X3D has two more physical cores and four more threads than the 7600X, it does claw back a win in the Multi-core scenario, beating it by a healthy margin of 24 percent here, too.

It's neck and neck for the two SSDs here as well, with both the Kingston Fury Renegade and Crucial T500 being neck and neck with one another, at 0 percent and 1 percent respectively. That's really quite impressive—in separate SSD specific testing, we've seen these two drives end up tied with one another in a number of scenarios, too. The T500 tends to have a slight edge in random 4K at Q32, while the Renegade wins out at Q1 by a healthy margin, too. In-game load times are tight between them, but the Renegade generally tends to wipe the floor with the T500 when it comes to file copy times.

SSD shenanigans aside, the core pricing is the real doozie, with a jump up between the two systems being quite surprising—our build today clocks in at $1,814 for the core components versus last month's $1,368. The price difference between the GPUs, particularly the AIB cards, is fairly substantial at this point, which is a shame. It seems that most of the Supers are now out of stock, or about to be, and prices are skyrocketing because of it. So much for the great deals and sub-$1,000 RTX 4080.

Nonetheless, our Flowy build still hits the mark when it comes to both 4K gaming and rendering prowess. For the time being, Intel does still seem to have the edge with its 14th generation chips, but it's worth considering that those chips in particular are drawing close to 50 percent more power than their Ryzen contemporaries, and crank up to 100 C to do that.

BENCHMARKS	ZERO-POINT	
Cinebench R23 Single-Core (Index)	2,031	1,801 (-11%)
Cinebench R23 Multi-Core (Index)	14,545	18,043 (24%)
CrystalDisk QD32 Sequential Read (MB/s)	6,987	7,034 (1%)
CrystalDisk QD32 Sequential Write (MB/s)	6,755	6,733 (0%)
3DMark Fire Strike Ultra (Index)	11,135	13,295 (19%)
Cyberpunk 2077 (fps)	29	36 (24%)
Cyberpunk 2077 RTX (fps)	20	24 (20%)
Metro Exodus (fps)	46	54 (17%)
Metro Exodus RTX (fps)	34	44 (26%)
Total War: Three Kingdoms (fps)	48	64 (33%)
Core Price	$1,368	$1,814 (32%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our zero-point consists of the RTX 4070 SUPER build from our last issue, featuring an AMD Ryzen 5 7600X, Nvidia GeForce RTX 4070 SUPER 12GB, Gigabyte X670 Aorus Elite AX Motherboard, 32GB (2x16GB) of Corsair Vengeance DDR5-5600, and 2TB Crucial T500 Pro M.2 PCIe 4.0 M.2 SSD. All games tested at 4K "Ultra" graphics presets with DLSS and V-sync turned off and XMP for RAM speed turned on. No manual CPU overclocking. "Core Price" refers to the key components generating performance (CPU, GPU, Mobo, SSD, RAM), not accessories.

The future of cable management?

Is there a better way? The BTF form factor says 'maybe'

CABLES—LOVE THEM or hate them, they've been a critical part of PC building since, well, we were building PCs. Over the years, these pesky connectors have developed considerably. From the humble days of the MOLEX and IDE connectors, to modern-day SATA, M.2, and 12VHPWR, as our PCs have got faster and more power hungry, so too have cables become streamlined and more efficient, catering to the whims of the PC builder.

Cases have developed special channels, rubber grommets, and cable tie-off points. No longer do we have great gobbets of them hanging loose across systems. Of course, we couldn't talk about cables without mentioning such things as braided and sleeved custom cables, hidden away in paracord, or the likes of Lian Li and its Strimmer RGB illuminated variants, too. Corsair and its iCUE Link software and its Unifans are also worthy of honorable mentions.

THE BTF FORM FACTOR

One of the slightly more surprising debuts we've seen in the last few months is the arrival of the BTF form factor. These are motherboards specifically designed to hide the vast majority of

GEFORCE RTX
REPUBLIC OF GAMERS
REPUBLIC OF GAMERS
START
FOR THOSE WHO DARE
GAME ON
74H
REPUBLIC OF GAMERS

The BTF form factor has been in development for a while, but products are now on the way.

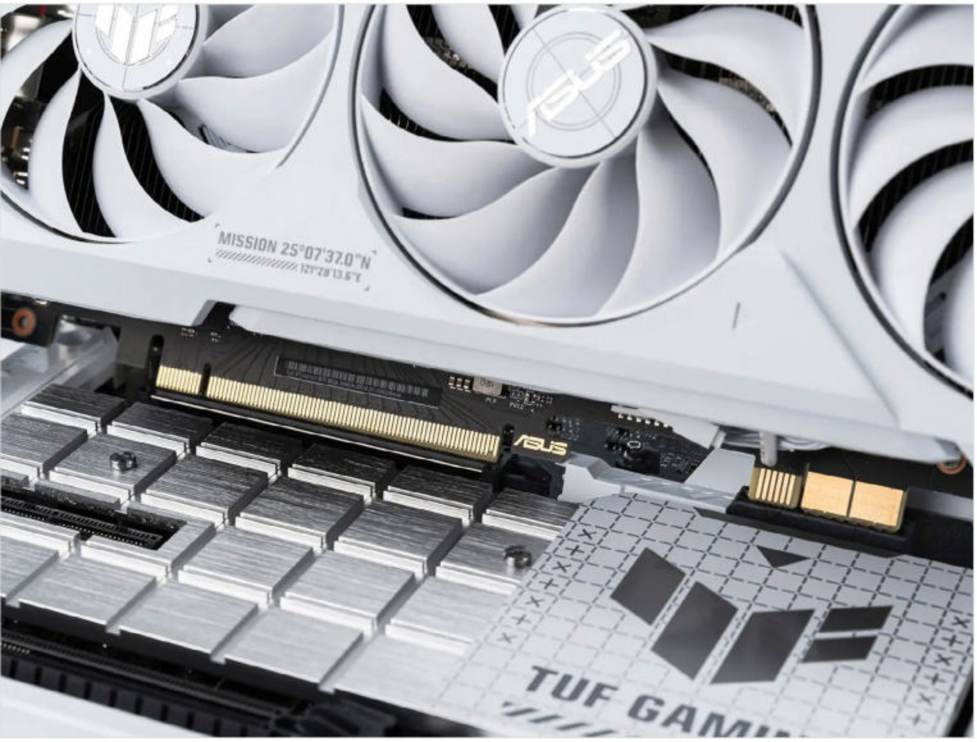
Join the conversation!

🤔 😗 😈 😕 😎 😛 😀 😱 🤓

Discuss all things PC gaming with fellow readers at our official forums
forums.pcgamer.com

PC GAMER

Cable management never used to be a priority, as you can see (right). This has now changed.



All the power being delivered by a custom PCIe slot legitimately sounds brilliant—let's get rid of pesky GPU power cables.

your motherboard's cables themselves by placing the connectors on the back of motherboard, hidden in the back of the case. We're not going full wireless just yet.

Asus is the biggest advocate of the 'back to the future' (yeah that's legitimately what it's called) form factor right now, and has finally launched a number of limited SKUs to facilitate it. A select few motherboards now feature the majority of their connectors on the back of the board directly—CPU power, 24-pin, USB headers, all of it.

Asus has even developed a specific single-power PCIe slot to help deliver all of the power needed for your RTX 40 series directly from the slot itself (as terrifying as that sounds).

THE MAXIMUM PC OPINION

Although an intuitive proposition, this seems like somewhat of a misstep—a 'Blu-ray versus streaming' moment. Generally speaking, the simplest and most convenient solution is usually the best, and despite the intrigue in moving your cables out of sight and into the back of the chassis itself, we've got to question whether a 24-pin and 8-pin power cable popping out of a tiny cable grommet is really so jarring that you'll want to spend additional cash on hiding it, particularly when there are already so many ways of customizing them.

That said, there is some impressive tech at work here, and some legitimately good ideas. For instance, if you can develop a PCIe slot for a graphics card that can deliver all of your GPU's power requirements, that's a smart step in the right direction, and one we can get behind being a feature on all motherboards. Do away with perhaps the most obtrusive cable—a mid-mounted 12VHPWR—and you'll make a number of aesthetic-loving system builders very happy.

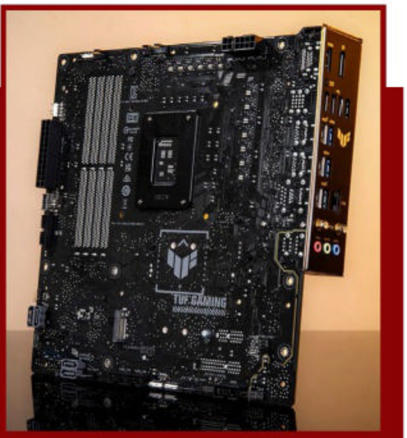
Ultimately (and thankfully), the market will decide BTF's fate, and whether it will sink or swim. Right now, call us cynics, but we'll stick with our sleeved cables for the time being. ⏻

NOT WITHOUT DRAW BACKS

This new BTF standard, although looking great, presents some significant challenges for the industry at large, notably when it comes to case design. We're already hearing of significant challenges from case manufacturers regarding the compatibility of these boards with existing product lines, particularly when it comes to mounting the hardware inside the case directly.

Not only that, but upcoming products supporting the BTF form factor now need to be designed with extra cutouts in mind, and ensure that the chassis has enough support on the stand-offs for the motherboard without compromising on the rigidity of the chassis.

Given that not everyone is working on developing the standard either, will this inevitably mean hardware manufacturers will have to cater to two types of design, one for each standard? Or will we end up with a 'jack of all trades, master of none' design school, with a range of mediocre cases instead? It's hard to predict right now.



Having all the power connectors and ports on the back can make case compatibility a major issue.

© ASUS

BUILD YOUR OWN NAS 2024

Build your own fast, low-powered, 24/7 server with the help of *Nick Peers*

ONE SERVER to rule them all. That's our dream—a single, centralized PC designed for always-on action, but which won't run up huge electricity bills. It needs to be able to run multiple services simultaneously, from media streaming to cloud sync and backup. It needs to be configured as headless machine, accessible from other devices on your network, and handle more than one connection, so friends and family can benefit from your NAS server.

For the past few years, we've been living the dream with the subject of our September 2022 build. It's as capable now as it was then, but we set ourselves the task of improving it in every way: a more powerful mobo that consumes even fewer watts? Check. Plenty of drive bays to allow us to easily expand storage? Check. Take up as little room as possible? Check. How about capping the price at $600 for the base unit? No problem.

The result? A pint-sized powerhouse that's not tied to proprietary technologies or operating systems, and one that will comfortably outlast even the best that Synology or QNAP has to offer the home market right now. Don't believe us? Turn the page to find out just how to spec, build, and set up your perfect NAS-like server.

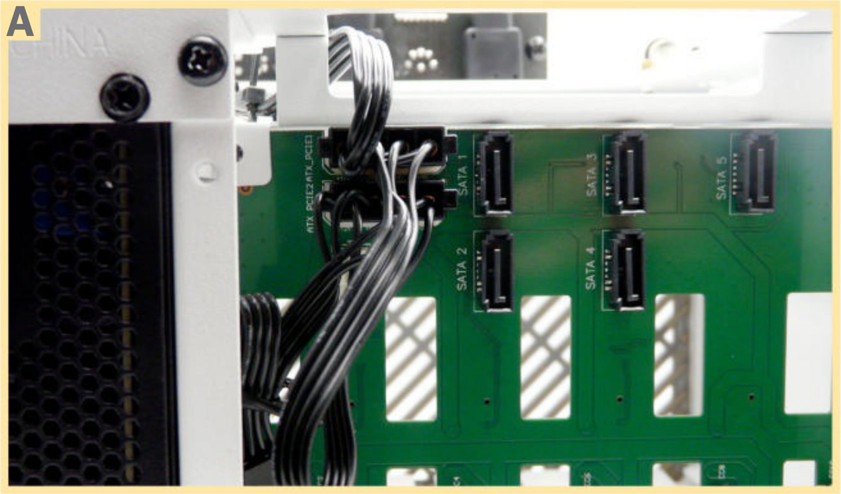
POWER
FUNCTION
INFO/ERROR
BenQ
File Edit View History Bookmarks Tools Help
Overview - nickdanp@N100-S
https://192.168.35.1:9090/metrics
Administrative access
Help
Session
Metrics se
nickdanp@
N100-SERVER
Search
System
Overview
Logs
Storage
Networking
Overview › Metrics and history
CPU
36 °C
4 CPUs
average: 2% max: 3%
View all CPUs
Load 1 min: 0.06, 5 min: 0.08, 15 min: 0.10
Service
%
user@1000
1.4
podman
0.5
syncthing@nickdanp
0.4
0.3
0.2
Memory
RAM
13.6 GB available
Service
Used
user@1000
12.0 GB
pod plex
9.60 GB
syncthing@nickdanp
2.60 GB
pod myjellyfin
814 MB
pod nextcloud
304 MB
Disks
Read
0
Write
114 kB/s
View per-disk throughput
/
109 GB free
/sys/firmware/efi/efivars
84.6 KB free
/home
453 GB free
/boot/efi
530 MB free
/home/nickdanp/media/bay3
2.68 TB free
/home/nickd bay4
5.95 TB total
3.07 TB free
Network
Interface
In
lo
403 B/s
enp2s0
4.44 kB/s
enp3s0
3.55 kB/s
bond0
7.99 kB/s
CPU
Usage
Load
Memory
Usage
Disk I/O
Usage

OUR PREVIOUS NAS build was centered around Intel's Gemini Lake Refresh range of Pentium Silver processors. ASRock produced a series of mini-ITX mobos with embedded J-series processors—passively cooled by heatsink for silent operation, but quad core and capable of handling all your server needs. But while Intel has updated its low-powered chips over successive generations, these have been restricted firmly to the tiny PC market. It's only with the launch of its Alder Lake-N line in 2023 that new mini-ITX mobos, sporting the latest N100 processor, have made an appearance.

Unsurprisingly, given the multi-generational gap between them, the quad-core, four-thread N100 comfortably outclasses even the top-line Pentium Silver J5040, achieving a Passmark CPU Mark of 5,623 versus the J5040's 3,395. That puts it in the territory of the i5-7400 or i3-9100, with one major advantage: while those chips had a TDP of 65 watts, the N100's TDP is a measly 6W (the J5040 is 10W). You also gain the benefit of an updated Intel UHD graphics chip, which ensures better hardware encoding of media streams when required.

When it comes to sourcing an N100 board, you have a choice of two models: AS Rock's N100DC-ITX ($129.99, www.newegg.com/p/N82E16813162133) and the ASUS PRIME N100I-D4 ($133.10, www.memoryc.com/44806). For the purposes of this build, we've chosen the ASUS PRIME because it works with a standard PSU. That way, if you're interested in upgrading your current NAS server, it's a simple process to swap out the old board (and RAM) for new.

The box opposite reveals the the components we've selected for this build. Although the board can theoretically support more than 16GB RAM, we've played it safe and kept the amount the same as our previous build, which we've never come close to maxing out. We decided against using a NVMe boot drive, because a SATA SSD is more than quick enough for server usage, plus we need the M.2 2280 port to expand the number of SATA ports available from the measly one on-board port supplied. This also leaves the solitary PCI-e slot free for other uses—in our case, we added a second Ethernet port to double the server's throughput.



Connect the PSU's twin Molex connectors to the SATA backplate.

CASE AND PSU CONSIDERATIONS

Last time out, we featured Jonsbo's compact N1 case. This time, we've chosen its roomier N2 case, which is still significantly smaller than the four-port InWin case we deployed when we first introduced the concept of a self-built NAS server in the April 2021 issue. With a compact footprint of just 222.5 x 222.5 x 224 mm, it will comfortably fit just about anywhere—ideally next to your router. Weighing just 2.9 kg, there's a built-in fan at the back of the unit to help keep the drives cool.

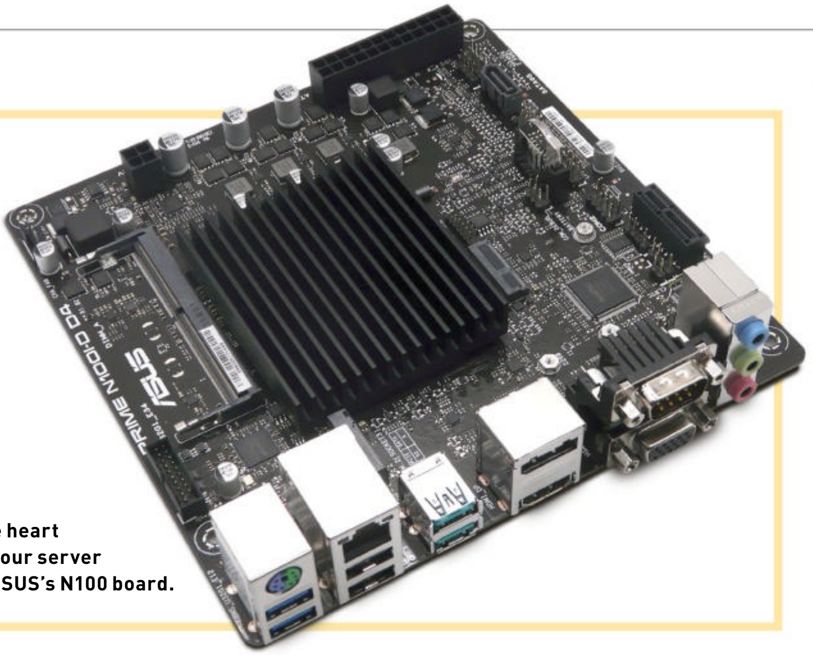
Because of the case's unique—and somewhat cramped—design, you won't be able to just pair any old PSU with it. First, the power supply needs to be SFX to fit the N2's frame, but you'll also need one with a long 24-pin connector cable to reach the mobo. After a false start, we settled on the Be Quiet 300W SFX Power 3 PSU. 300 watts is overkill, but the 350mm 24-pin connector is one of the longest we could find on an SFX power supply, and fits snugly. The PSU also met our needs by offering two separate cables for powering the drives—one with SATA, the other offering two separate 4-pin Molex connectors to provide power to all five storage drives via the N2's SATA backplane.

OTHER CONSIDERATIONS

You'll also need six SATA cables to hook up all available drives. Five of these connect via the case's backplane, and thanks to the cramped design, they'll need to be right-angled at one end. They also need to be the right length—following online advice, we chose 20-inch cables, which easily reach the M.2 SATA adapter on the motherboard without taking up too much room. Try searching newegg.com for 'right-angle sata cable' to check out available offers—a pack of five can be had for as little as $10.99 including shipping (www.newegg.com/p/0ZF-0187-00004). The other cable that connects your SATA boot drive to the mobo's native SATA port should also be 20 inches—this can be straight at both ends.

One cost we've not factored into the main build is that of additional storage. The Jonsbo N2 case can accommodate up to five 3.5-inch hard drives, allowing you to grow your storage over time as your needs expand. When shopping for storage, we recommend you choose drives built specifically for life in a 24-7 system. We've been using Western Digital's Red series of drives for a

The N100 only supports a single stick of SO-DIMM DDR4 RAM.



The heart of your server is ASUS's N100 board.

decade now with no problems, and we've also dabbled successfully with a Seagate IronWolf drive. Toshiba's N300 series is another option.

These days, there are capacities to meet even the most storage-hungry user—our own setup has evolved to house 27 TB of storage, spread across five drives (1x 8TB, 2x 6TB, 1x 4TB and 1x 3TB). There's no major premium to pay for WD Red storage, either—Western Digital's WD Red Plus brand offers capacities from 4TB ($99.99) up to 14TB ($259.99), allowing you to connect up to 70 TB of storage to your NAS—see www.westerndigital.com/products/network-attached-storage/hdd for details.

BUILD YOUR NAS

Putting it all together is complicated by the size and layout of the Jonsbo N2 case. Start by pulling off the front grille to reveal the drive bays—you'll see a small Allen key held in place on the right. You'll need this to remove the four non-standard screws. Remove the top to reveal the motherboard's bay along with a set of cables to the front ports—unlike most cases, the mobo sits on top of the drive and PSU bays. You'll see a gap beneath the mobo tray and the top of the drive bays—this provides space for trailing cables to and from the PSU bay, but requires you to build the server in a specific order.

The compact Jonsbo N2 is the perfect case for your NAS server.

Turn your attention to the back of the case. Remove the rear grille on the right to reveal the case fan. This helps to cool the drives, and should be sufficient in most cases (our drives idle at under 80 F, even with all five bays filled). Behind this, you'll see the SATA backplane, with five SATA data ports and two Molex power ports, delivering power to all five drives. There's also a connector for the case fan, but ignore this.

Finally, there's the PSU holding plate to its left. Remove this, and you'll be ready to start fitting components.

FIT THE PSU

Start with the PSU—slide this in with the power cables at the bottom to give them room to maneuver, then separate the cables so the 24-pin, 12V 4-pin, and SATA power cables are all up in the back left corner of the case. The twin Molex (4-pin) power lead needs to be threaded through to the front and plugged into the two power ports on the SATA backplane, as shown in [Image A]. Secure the PSU to the holding plate.

There's not much space between the backplane and the back of the

OUR 2024 NAS BUILD SPEC

Looking to emulate our build? Here's what you need, how much it should cost—and where to find it:

MOBO
ASUS PRIME N100I-D D4
Onboard Intel N100 processor, 1x SO-DIMM DDR-4 RAM slot (up to 16GB), 1x M.2 (PCI 3.0 x2) and 1x SATA 6Gb/s slots, 1x PCIe 3.0 x1 slot, M.2 Wi-Fi slot, 1x 1Gbps Ethernet, 6x rear USB ports (2x 3.2 Gen 2, 2x 3.2 Gen 1, 2x USB 2.0), 2x Front USB headers (1x USB 3.2 Gen 1, 1x USB 2.0), DisplayPort/HDMI/VGA ports
(***$145, www.memoryc.com/44806***)

RAM
Kingston KVR32S22D8/16—16GB SO-DIMM DDR4, 3200MT/s,
Non ECC (***$39.99, www.amazon.com/dp/B07ZVHBSNG***)

PSU
Be Quiet Power 3—300W
SFX form factor (***around $73, www.amazon.com/dp/B0937GNL7W***)

BOOT DRIVE
WD Red SA500 SSD—1TB
SATA III 6Gb/s, up to 560 MB/s
(***around $90, www.amazon.com/dp/B07YFG3R5N***)

CASE
JONSBO N2 Mini-ITX NAS Chassis – ITX form factor
SFX PSU slot, 1x low-profile PCI-e slot, front I/O port with 1x USB 3.0 type A, 1x USB 3.2 Gen 2 Type C and headset/mic 3.5mm. (***$149.98, www.amazon.com/dp/B0BQJ6HHXJ***)

SATA ADAPTER
ORICO M.2 M
Key to 6-port SATA 3.0 adapter card (***$35.99, www.newegg.com/p/17Z-0003-00027***)

(Optional)
2.5GB/S ETHERNET PORT
StarTech ST1000SPEX2 - 1-port, 1Gbps, PCIe, dual profile (***around $33, www.newegg.com/p/N82E16833114081***)

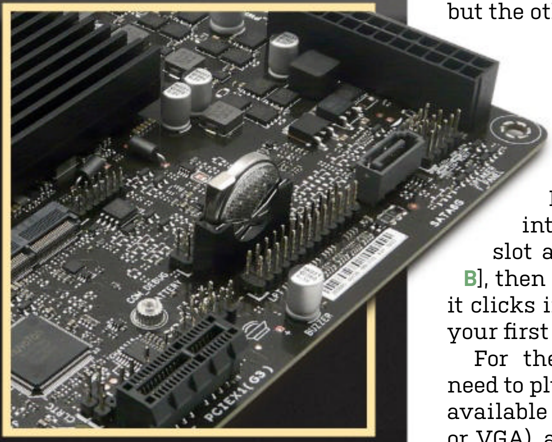
TOTAL OUTLAY (***not including additional storage)***: around $565

TROUBLESHOOT YOUR BUILD

If all is well, you shouldn't run into any problems with your build. But if you do experience issues, then the PRIME N100 board supports troubleshooting via the N2 case's power light to potentially guide you to a solution. For a guide to how it works, visit www.asus.com/support/faq/1046157.

If the build progresses smoothly at first, but then falls over when you introduce some of the later components (such as the network card), you may find yourself falling back on the old 'wipe the CMOS and start again' method. In many cases this should settle things down enough for you to strip back to the basic build, then reintroduce each new component without further problems.

However, if you find yourself stuck even at this point with the PC stubbornly hanging at boot with four-second bursts of light on, light off, then there is a nuclear option: the mercury cell short-circuit method. It involves removing the CMOS battery, then placing a screwdriver into the battery socket so it touches both sides. Hold it here for about a minute, then replace the battery, and everything should be fully reset—see www.asus.com/support/faq/1040820 for details.



Be prepared to short the CMOS battery circuit when troubleshooting.

case, so try to tidy the Molex cable so it's not blocking the case fan. Next, plug in the five SATA cables at their right-angled ends, and push the cables up through the hole on the right-hand side of the case. Again, make them as tight as possible to leave plenty of space and air. Finally, untie the case fan's power cable and thread it through to the PSU bay in the opposite direction to the Molex connector so it joins the other cables at the back of the case. This is because you'll use the mobo's own chassis power connector, as it's able to regulate the fan speed and make things quieter. Reattach the case fan and the grille back to the chassis.

INSTALL THE MOBO

The next job is to fit the motherboard backplate, followed by the motherboard itself, using the four screw holes on the chassis to line it up. Gently push the mobo against the backplate before securing it using the washers and screws supplied with the case. We recommend going diagonally—the rear right screw first, followed by the front left, rear right, and the front right screws.

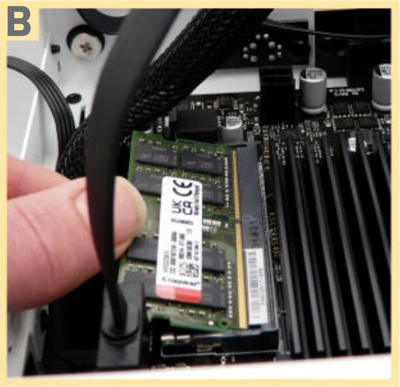
Next, attach the case fan to the CHA_FAN connector on the motherboard (it's next to the PSU bay). Now, attach both power cables—the 24-pin will be a tight fit, even with a 350 mm cable, but don't forget the 12V 4-pin connector. If you're upgrading from a J-series system, it's easy to forget this (like we did), as it isn't required on the older mobo.

Next, follow the instruction manual to attach the front panel headers—there's no onboard connector for the USB-C port sadly, but the others can all be connected.

FIT RAM AND TEST

Once in place, it's time to fit the solitary SO-DIMM RAM stick. It's a case of introducing the RAM to the slot at a 30-degree angle [Image B], then pushing in and down until it clicks into place. Now, it's time for your first boot test.

For the purposes of this, you'll need to plug in a monitor to one of the available ports (HDMI, DisplayPort, or VGA), along with a keyboard and, of course, a power cable. Flick the PSU power switch button on, and



Introduce the RAM to the RAM slot at a 30-degree angle.

then press the button at the front of the case.

If all is well, the button should flicker and then show a solid white light, and you should find yourself in the BIOS. The main screen should verify the processor (N100, base frequency 800 MHz) and RAM installed (16,384 MB, 3200 MHz frequency). Simply press the power button to switch off and continue with the build. If it doesn't come on, check the troubleshooting box for some steps to follow.

FINISH THE BUILD

Next, fit the SATA SSD drive to its housing at the front left of the case above the PSU [Image C]. From here, you can connect the SATA power connector from the PSU, then thread a SATA data cable from the drive over to the mobo's solitary SATA port on the far side of the case next to the front panel connectors.

Next, it's time to fit the six-port SATA adapter. It's fitted like a regular NVME drive, but make sure you screw in the supplied riser so that it aligns horizontally with the NVME slot, then push it in and screw it down, as seen in [Image D]. Once done, plug in the data cables you've connected to the SATA backplane. In an ideal world, you'll marry up SATA1/2/3/4/5 on the backplane to the equivalent marked slot on the NVMe adapter, but it's not mandatory.

Now's a good time to perform another boot test. You can verify that the drive has been correctly identified from the BIOS setup utility via the Advanced > PCH Storage Configuration screen. While the server will recognize any drives attached via the NVMe SATA adapter

C

Western Digital
1 TB
SOLID STATE DRIVE
SATA SSD
WD Red SA500

There's space for the SATA SSD boot drive next to the mobo.

at startup (they're listed as M.2 drives in the BIOS POST test), you can't view their status via the BIOS setup utility.

The final step—if you've decided to fit one—is the Ethernet adapter (don't forget to switch to the low-profile backplate, as shown in [Image E]). Perform one last boot test, and if all is working as it should, you can power down one final time. Make sure your cables are as tidy as possible to ensure airflow is good, and finally hide it all away underneath the top of the case, which you reattach using the supplied Allen key.

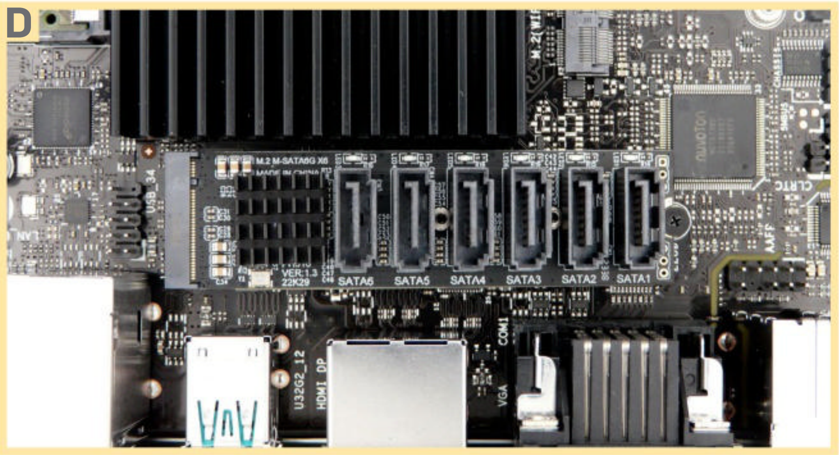
BIOS SETUP

You're now ready to get your server up and running. Let's start with the BIOS. While there's no fancy UEFI interface to work with, the N100's BIOS is still comprehensive, packed with plenty of tweakable features. While there's little actual tweaking required at this point—it's pretty much optimized out of the box—now's a good time to update it.

Start by downloading the latest BIOS: go to www.asus.com, click the search button, and type 'N100I-D D4' into the search field before clicking PRIME N100I-D D4 (not the CSM entry) under Support. Select Driver & Utility > BIOS & FIRMWARE, then download the latest release—0405 at time of writing. Save this zip file to your PC, then extract the PRIME-N100I-D-D4-ASUS-0405.CAP file inside onto a USB flash drive, formatted as FAT32.

Plug this into one of your server's USB ports, then open the BIOS setup utility and navigate to 'Tool > Start ASUS EzFlash'. Follow the prompts to select the CAP file from your flash drive (it'll be the second drive listed), then let EzFlash do the rest. Once loaded, you'll reboot to the POST screen, and will need to press F1 to continue. Press F10 to save and exit, and your hardware build is complete.

D



We've used the M.2 slot to add additional SATA ports.

PREP INSTALL MEDIA

It's time to install your new operating system. Our past NAS-server builds have been based around Ubuntu LTS, so if you're upgrading from an older system and are happy with using that, reconnect your old storage drives (see below), then boot from that to carry on from where you left off. Alternatively, to carry on with a fresh Ubuntu install, consult our September 2022 issue.

We've decided to switch to Debian Server. Our main reason is that we're changing our container-based system to Podman, which is better supported on Debian. That said, there's not a lot of difference between the two—Ubuntu is based on Debian, after all—and after we've set you up, it'll all feel quite familiar if you do take the plunge. It's distributed as an ISO image, so start by going to https://debian.org, and clicking the large Download button to save the streamlined net-based installer (628 MB)—debian-12.4.0-amd64-netinst.iso—to your Downloads folder.

Next, we recommend installing Ventoy (www.ventoy.net) to a spare USB flash drive if you've not done so already, then simply copying the ISO file to the drive. You're now ready to install Debian 12.4 Bookworm.

INSTALL DEBIAN SERVER

Boot your new server from the USB drive—it should detect it automatically as the only bootable option. If not, enter the BIOS and select the flash drive from the 'Boot override' section of the Boot menu. When the Ventoy menu appears, select debian-12.4.0-amd64-netinst.iso to boot from that image. When prompted, choose 'Graphical Install'. Work your way through the initial steps of the wizard, setting your language and location, and configuring your keyboard—this merely sets things up for the installer itself.

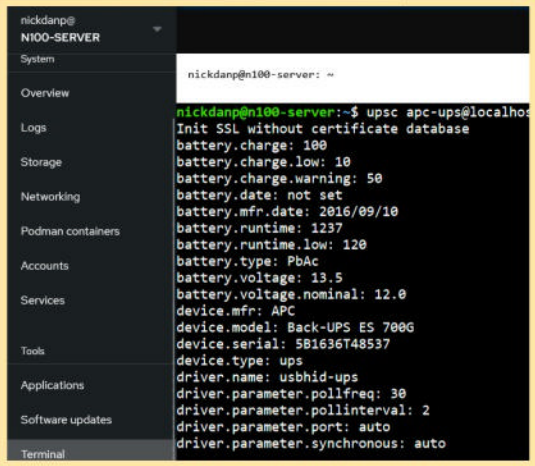
The first thing the installer does is look for your network interface—or interfaces, if you've fitted the optional PCI-e network card. If more than one is found, you'll be prompted to choose which one is your primary—so long as they're both plugged into your network, it doesn't matter which you choose. From here, it'll configure the network with a DHCP address, which we'll change later.

UPS BACKUP

The last thing you want is for a power outage to disrupt all your running services and potentially corrupt your entire Debian installation. To protect your server 24-7, therefore, you need to plug it into a UPS so it survives brownouts or simple trips in your home's electricity supply. While most UPS's like CyberPower's 450VA backup ($58, www.bestbuy.com/site/6239405.p) provide simple battery backup, giving you time to either restore the electricity or manually shut down your server gracefully, what happens if the outage occurs when you're away from home?

The solution lies with a smart UPS system—one that connects by USB to your server and which can shut it down automatically after a set period or when the battery drops to a certain level. There's not much of a premium to pay, either—Tripp Lite's INTERNET350U system can be had for as little as $68 (https://www.amazon.com/dp/B00007FHDP) for its 350VA/180W system, or $81 for the 550VA/300W system.

Once hooked up to your NAS, you'll need to configure Debian's nut (Network Up Tools—https://networkupstools.org) tool. See https://zackreed.me/installing-nut-on-ubuntu for one of many guides to using nut with the usbhid-ups driver that supports the Tripp-Lite system (tip—type 'su –' before following the guide).



```
nickdanp@n100-server:~$ upsc apc-ups@localhos
Init SSL without certificate database
battery.charge: 100
battery.charge.low: 10
battery.charge.warning: 50
battery.date: not set
battery.mfr.date: 2016/09/10
battery.runtime: 1237
battery.runtime.low: 120
battery.type: PbAc
battery.voltage: 13.5
battery.voltage.nominal: 12.0
device.mfr: APC
device.model: Back-UPS ES 700G
device.serial: 5B1636T48537
device.type: ups
driver.name: usbhid-ups
driver.parameter.pollfreq: 30
driver.parameter.pollinterval: 2
driver.parameter.port: auto
driver.parameter.synchronous: auto
```

Once set up, 'nut' will allow you to access and control your UPS.

For now, you'll be prompted for a hostname (debian by default, but you might prefer something more identifiable, such as n100-server). When prompted for a domain name, enter something you'd subsequently use with all your local devices (the .internal suffix is likely to become the standard for this, such as mynetwork.internal), but you can leave it blank and click Continue.

The next step is critical: setting the root password. Unlike Ubuntu, this password is separate from your user password, so should be different (and strong) for security reasons—write it down, as you'll rarely use it, but could lock yourself out of parts of your system if you forget it.

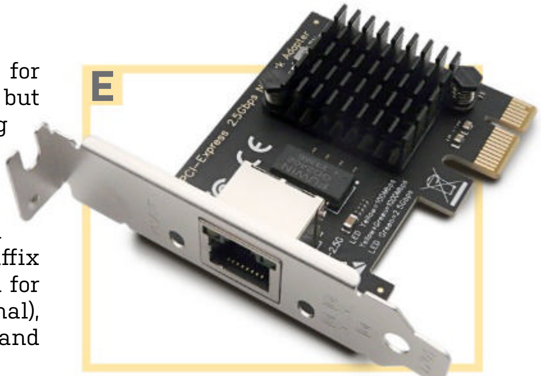
From here, you'll set up your main user: enter your full name, which will generate a suggested username that you're free to change. If you're migrating from an old server, we recommend choosing the same username to avoid permissions issues with existing drives when you port them across. Finish by setting a password for your user account, then choose your time zone.

PARTITION YOUR DRIVE

The next step is to configure and partition your boot drive. Click Continue after each step to proceed. First, choose the manual option, then select your SSD drive from the list, followed by Yes to create a new empty partition table on the drive. Click Continue, and you should see that the drive now has 1.0 TB of free space.

Select the free space, then select 'Create a new partition'. Enter 540 MB. Leave Primary selected, followed by Beginning. You'll see the drive is currently set as 'Ext4 journaling file system'—leave this selected and click Continue. Choose 'EFI System Partition' from the list, return to the main screen, and select 'Done setting up the partition'.

The drive has been updated to show an ESP partition. Select the free space below this, and follow the previous steps, allocating 128 GB (or 64 GB on a smaller boot drive) to it. Again, leave Beginning selected. Verify that it's set to Ext4... and that the mount point is /. Again, select 'Done setting up the partition', and repeat the process one last time, this time leaving all available space selected. The partition should be automatically created as Ext4... with /home as its mount point.



If you're fitting an Ethernet card, don't forget the low-profile bracket.

Again, select 'Done setting up the partition', verify the disk has been split into three, as shown in the screenshot (don't worry if there's free space at either end of the drive) before choosing 'Finish partitioning and write changes to disk'.

Click Continue. You'll be warned that you haven't created a swap partition—don't worry about this; although we've never needed one in three years of running Ubuntu Server with 16 GB RAM, we'll create a swap file in Debian later. Select No, Continue to review your proposed partition layout one last time, then choose Yes, followed by Continue.

COMPLETE INSTALLATION

Debian should now proceed to partition your drive, and then install its 'base system'. Once complete, you'll be prompted to configure the package manager. Skip any prompts to insert additional install media, then choose a mirror close to your home (or default to the safe deb.debian.org). You should be able to skip the http proxy prompt, then it's a case of selecting what additional software to install.

You'll see the installer selects a desktop environment by default—as your server will be 'headless', uncheck this before clicking Continue.

Once complete, you'll be prompted to remove your USB drive (unnecessary, as your server is already configured to boot from the main SATA port), then restart to boot

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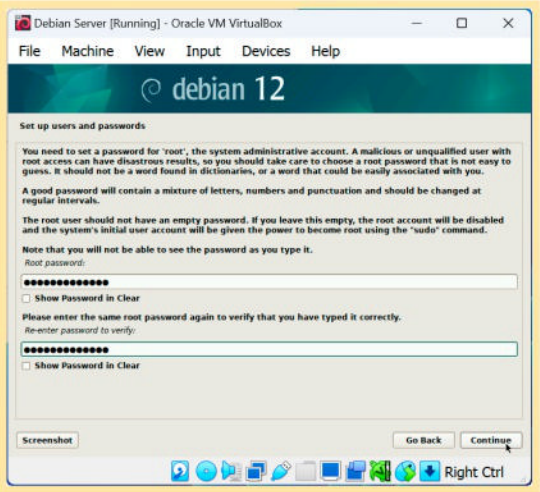


Debian Server [Running] - Oracle VM VirtualBox

Set up users and passwords

You need to set a password for 'root', the system administrative account. A malicious or unqualified user with root access can have disastrous results, so you should take care to choose a root password that is not easy to guess. It should not be a word found in dictionaries, or a word that could be easily associated with you.

A good password will contain a mixture of letters, numbers and punctuation and should be changed at regular intervals.

The root user should not have an empty password. If you leave this empty, the root account will be disabled and the system's initial user account will be given the power to become root using the "sudo" command.

Note that you will not be able to see the password as you type it.

Root password:

●●●●●●●●●●●●●●

☐ Show Password in Clear

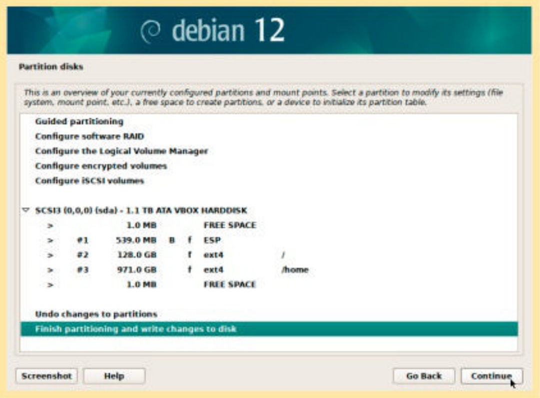
Please enter the same root password again to verify that you have typed it correctly.

Re-enter password to verify:

●●●●●●●●●●●●●●

☐ Show Password in Clear

You need a separate password for the root user in Debian.



Partition disks

This is an overview of your currently configured partitions and mount points. Select a partition to modify its settings (file system, mount point, etc.), a free space to create partitions, or a device to initialize its partition table.

```
Guided partitioning
Configure software RAID
Configure the Logical Volume Manager
Configure encrypted volumes
Configure iSCSI volumes

▽ SCSI3 (0,0,0) (sda) - 1.1 TB ATA VBOX HARDDISK
    >           1.0 MB          FREE SPACE
    >   #1    539.0 MB   B  f   ESP
    >   #2    128.0 GB      f   ext4         /
    >   #3    971.0 GB      f   ext4         /home
    >           1.0 MB          FREE SPACE

Undo changes to partitions
Finish partitioning and write changes to disk
```

Once partitioned, your drive should look like this.

into Debian proper. You'll see a series of text messages scroll by before you're prompted to log into your new installation for the first time.

BASIC SETUP

Once logged in, install 'sudo', which will allow you to run administrative commands without logging on as the root user. First, type 'su -' and press Enter, then enter the root password you set up to switch to the root@server-name prompt. Now, input the following commands, substituting 'user' in the final command with your Debian username:

```
apt update
apt install sudo -y
usermod -aG sudo user
```

Verify your username is a member of the sudo group ('groups user'—substitute user with your username), and reboot ('reboot -h now') to confirm the change.

After logging back in, create a 4 GB swap file, then confirm its existence:

```
sudo fallocate -l 4G /
swapfile
ls -lh /swapfile
```

It's time to install our web front-end so you can manage your server remotely. We're going to install the latest version of Cockpit (https://cockpit-project.org) using Debian's 'testing' repository, which isn't configured by default:

```
sudo nano /etc/apt/
sources.list
```

Add the following two lines beneath the last deb-src line in the list:

```
deb http://deb.debian.org/
debian/ testing main non-
free contrib
deb-src http://deb.debian.
org/debian/ testing main
non-free contrib
```

Press Ctrl + X, press Y and hit Enter to save the file. Next:

```
sudo nano /etc/apt/
preferences
```

This will create a new empty text file. Fill it, as shown in [Image F]. Save and exit. Lastly:

```
sudo nano /etc/apt/apt
.conf
```

This creates another empty file, which needs to be filled with the following line:

```
APT::Default-Release "bookworm";
```

Save and exit. You're finally ready to install Cockpit:

```
sudo apt update && apt install -t
testing cockpit cockpit-pcp
```

LOG IN REMOTELY

Type exit and hit Enter to return to your own user account, then type 'ip addr' and press Enter to find out your server's IP address. Make a note of this, then type exit and press Enter to return to the Debian login screen. Switch to your main PC, open a web browser, and go to https://192.168.x.y:9090 (192.168.x.y is your IP address).

You'll see a warning about a potential security risk—this is an

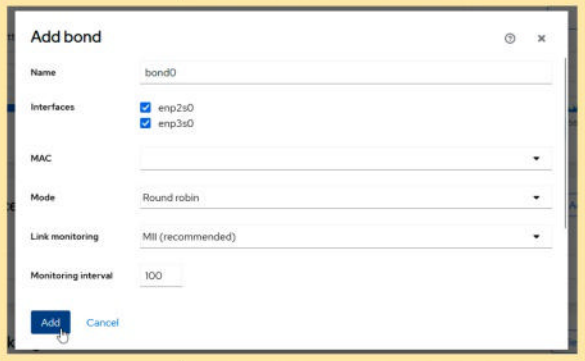
IMPROVE NETWORK PERFORMANCE

Another upgrade is the addition of a second Ethernet port. Thanks to Linux's support for 'bonding', you can combine two separate Ethernet interfaces. It doesn't double transfer speeds, but it does double throughput. It also provides a measure of redundancy—if one port fails, the other will continue to work.

Support for 'bonding' is built into Cockpit. Navigate to Networking, where you'll see both interfaces listed—so long as both are connected to your network via Ethernet cables, they should have independent IP addresses and traffic.

To combine the two, click 'Add bond'. Leave the name as bond0, then check both interfaces. Set the Mode to 'Round robin', leave the other options as they are, and click Add. You'll see the Interfaces replaced by a single 'bond0' entry, and after a short period you'll be logged out, as a new IP address has been allocated to the bond.

Use a tool like Advanced IP Scanner (www.advanced-ip-scanner.com) to find out what the new IP address is, then log back in through that (https://192.168.x.y:9090). Again, you'll need to grant yourself administrative access. Once done, return to the Networking section, where you should see 'bond0' is listed. This works in the same way as a regular Ethernet interface, so click its entry and follow the prompts in the text to allocate it a static IP address going forward.



Add bond

Name: bond0

Interfaces: ☑ enp2s0 ☑ enp3s0

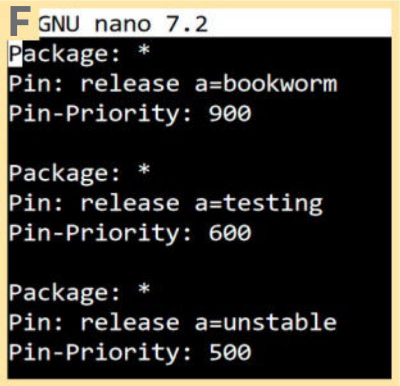
MAC:

Mode: Round robin

Link monitoring: MII (recommended)

Monitoring interval: 100

Combine two Ethernet interfaces using round robin networking.

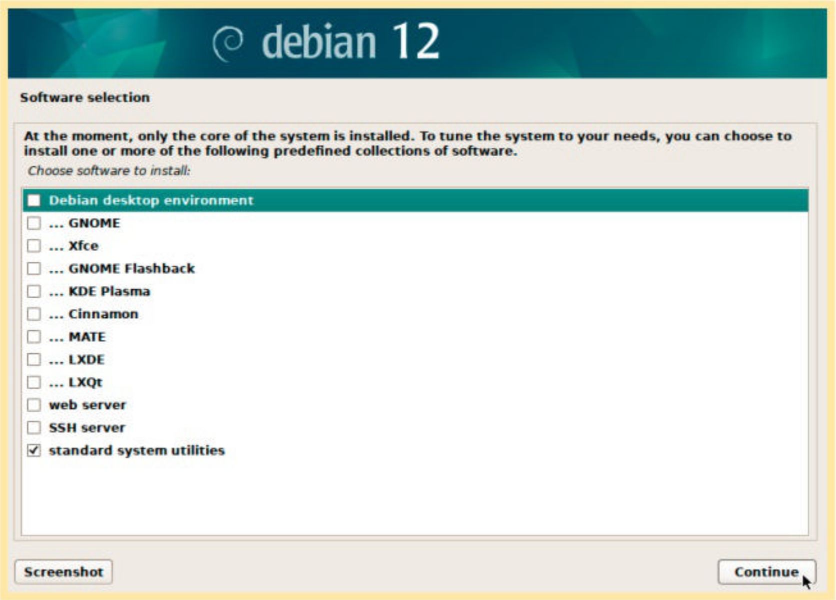


```
GNU nano 7.2
Package: *
Pin: release a=bookworm
Pin-Priority: 900

Package: *
Pin: release a=testing
Pin-Priority: 600

Package: *
Pin: release a=unstable
Pin-Priority: 500
```

Add these lines to the /etc/apt/preferences file.



Software selection

At the moment, only the core of the system is installed. To tune the system to your needs, you can choose to install one or more of the following predefined collections of software.

Choose software to install:

- ☐ Debian desktop environment
- ☐ ... GNOME
- ☐ ... Xfce
- ☐ ... GNOME Flashback
- ☐ ... KDE Plasma
- ☐ ... Cinnamon
- ☐ ... MATE
- ☐ ... LXDE
- ☐ ... LXQt
- ☐ web server
- ☐ SSH server
- ☑ standard system utilities

Make sure you don't install any desktop—it's redundant.

internal IP address, so it's safe to proceed. If you're a Firefox user, click Advanced... followed by 'Accept the Risk and Continue'. You'll find yourself at the Cockpit login screen. Enter your Debian username and password, and click 'Log In'. You'll find yourself at the web interface you'll use going forward to administer your server. Start by clicking 'Turn on administrative access', re-enter your user password, and you're good to go.

For a detailed tour of cockpit, check out the September 2022 issue, where you'll discover that you have access to detailed metrics (including CPU and RAM usage, as well as temperatures across your server), logs, and a fully functional Terminal. There are also modules for configuring your storage, networking, accounts, and services, plus a convenient 'Software updates' section. It really is an all-round better experience than relying solely on a command-line interface.

However, don't relax just yet. You'll note that your primary network interface is currently set to unmanaged under Networking, meaning you can't edit it. To fix this, switch to Terminal, and input the following command:

```
sudo nano /etc/NetworkManager/
NetworkManager.conf
```

Look for the line marked 'managed=false' under [ifupdown]. Change this 'managed=true', then press Ctrl + X. Press Y, followed by Enter. Now, reboot.

Return to the Networking section, where you should see the interface is listed (if you installed a second Ethernet interface, you'll see that two are listed—see the 'Improve network performance' box for details of setting these up as a single 'bond' for maximum performance). It's time to assign a static address to your server: click the interface name to view its properties, then click next to IPv4, set it to manual, and input your desired IP address. The netmask should be set automatically at 255.255.255.0, while you should make sure the Gateway points to your router's IP address. Click Save.

Cockpit will test if the connection works, then warn you the current connection will be lost if you proceed. Click 'Change the settings', wait a few moments until the 'Disconnected' sign appears, then switch to using the new IP address—in our example, https://192.168.35.1:9090.

SET UP ADDITIONAL DRIVES

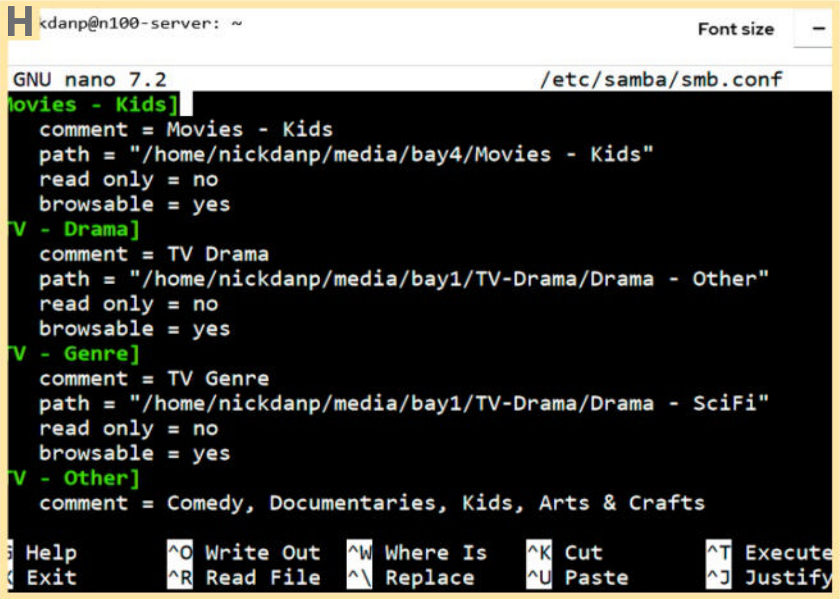
It's time to set up your NAS's storage drives. Start by fitting them with the rubber gromits and handle that's required to slot them into place in the Jonsbo N2 case, as shown in [**Image G**]. They then slide into whichever slot you want to use for each one, making sure their ports are lined up correctly with the SATA backplane. Push them in until you feel them click into place.

The drives are managed via the Storage section in Cockpit. For a detailed guide to setting up newly formatted drives from scratch, refer to our September 2022 guide. If you're migrating drives across from your old server, you shouldn't repartition or format the drive, otherwise you'll lose any data on it.

Instead, you should see the drives (and their partitions or 'volumes') are already visible—sdb is the drive, sdb1 the volume. All you need to do is mount each one in turn. Click the first volume (sdb1) to access

These rubber gromits secure your drives to the N2's storage bay.

© DEBIAN



```
kdanp@n100-server: ~
 GNU nano 7.2                               /etc/samba/smb.conf
ovies - Kids]
   comment = Movies - Kids
   path = "/home/nickdanp/media/bay4/Movies - Kids"
   read only = no
   browsable = yes
V - Drama]
   comment = TV Drama
   path = "/home/nickdanp/media/bay1/TV-Drama/Drama - Other"
   read only = no
   browsable = yes
V - Genre]
   comment = TV Genre
   path = "/home/nickdanp/media/bay1/TV-Drama/Drama - SciFi"
   read only = no
   browsable = yes
V - Other]
   comment = Comedy, Documentaries, Kids, Arts & Crafts

 Help       ^O Write Out  ^W Where Is   ^K Cut        ^T Execute
 Exit       ^R Read File  ^\ Replace    ^U Paste      ^J Justify
```

Edit the smb.conf file to create network shares.

its properties page, then click the tricolon () button next to 'ext4 filesystem' and choose Mount. Input the mount point—for example, '/home/your-debian-username/media/bay1' and leave the other options as they are (including 'Mount without waiting, ignore failure' under 'At boot'). Click Mount, and the drive should now be accessible.

To verify this, switch back to the Terminal, type 'ls -l' and press Enter. You'll see that a media folder has been created, but the problem is that it's currently owned by root. To avoid having to use 'su –' to access it, we need to change both it and its subfolders (bay 1 and so on) so they're owned by your user account. This can be done with just one command (substitute 'username' with your Debian username in both instances):

```
sudo chown -R username:username media
```

Once done, you should be able to navigate to the bay1 folder (cd media/bay1) and view its contents (ls -l) to verify that the drive (and its contents) are now visible.

MORE CONFIGURATION TIPS

As things stand, you've built your server, configured it for headless access, assigned a static IP so it's easy to find on your network, and discovered how to plug in additional storage drives. The next step is to set up any shared folders you'd like others to access.

This is done by installing the 'samba' package along with a package called 'wsdd' that makes your server visible from Windows machines:

```
sudo apt install samba wsdd
```

Once in place, edit the smb.conf file using the nano text editor ('sudo nano /etc/samba/smb.conf') using the syntax shown in [Image H], which is largely self-explanatory (again more details in the September 2022 issue). You'll also need to set up a special sharing password for your username ('sudo smbpasswd -a username') to allow access from other machines.

If you were simply looking at a NAS for file sharing and backup, you'd now effectively be done, but why stop there? This NAS server is designed to run multiple services, from the likes of Plex and Jellyfin for media streaming, to Nextcloud for data backup and sync, and Vaultwarden for password management. Some packages can be installed natively, but we suggest you familiarize yourself with Podman (or Docker if you installed Ubuntu). The final box reveals how to get it installed. Have fun with your new build, and if you run into any problems, give the Doctor a call! ⏻

SET UP PODMAN

Our main reason for choosing Debian Server as our OS was to run a later version of Podman. Version 4.3.1 is available in the default repos, but because we've enabled the testing repo to install Cockpit, you can install the very latest version (4.9.3 at time of writing) with the following command:

```
sudo apt update && sudo apt install -t testing podman
```

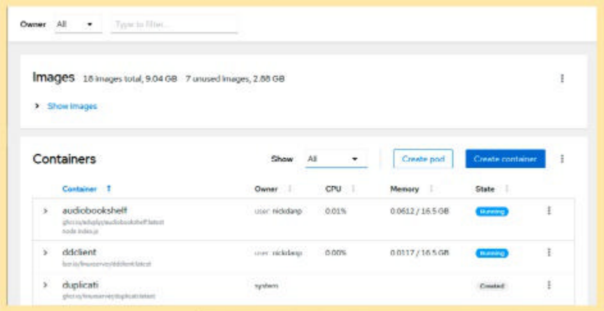
Once it's in place, install the Cockpit plugin, which allows you to monitor running containers and create new ones without having to use the Terminal, if you wish:

```
sudo apt install -t bookworm-backports cockpit-podman
```

Once installed, click the Session button, choose 'Log out' to log off Cockpit, then log back in. You'll see a new entry—Podman containers—on the left—select this to verify that Podman is running. You'll see an option to start 'User Podman service'—click Start to enable rootless Podman, allowing you to run containers as your own user, as opposed to root.

You can start exploring Podman—our guide in the February 2024 issue is a good place to start. Although written for Windows, it's easily translated, and you'll find that the Cockpit plugin is actually more responsive and simpler to use than the Podman Desktop tool for Windows. There's also no need to faff about with binding ports.

Indeed, many of our previous guides for Docker can be translated to Podman—substitute 'docker' with 'podman', and you're good to go in most circumstances. That said, there are peculiarities to running some containers rootless, so if you run into any problems then drop the Doctor an email.



Images 18 images total, 9.04 GB 7 unused images, 2.88 GB

Containers

Container	Owner	CPU	Memory	State
audiobookshelf	user: nickdanp	0.01%	0.0612 / 16.5 GB	Running
ddclient	user: nickdanp	0.00%	0.0117 / 16.5 GB	Running
duplicati	system			Created

Cockpit offers a plugin to allow you to monitor Podman containers.

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PC BUILD GUIDE

Strap in as we divulge 20 more tips on how to become the next master PC builder

By Zak Storey

HERE AT MAXIMUM PC, we're specialists when it comes to, you know, building PCs. It is our bread and butter, and we've been doing it for a heck of a long time now. This journalist alone has logged no less than 63 separate build logs in these hallowed pages, and built many more. Along the way, we've picked up a ton of tips and tricks to make the process as painless and seamless as possible.

It's this knowledge, these ingrained, subtle refined notions and ideas, that have turned even the most challenging of concept system builds into paltry, simple, and easy-to-produce machines of mayhem. They can be crafted on a whim, and knocked out in less than a few hours. Here, we'll be divulging all that information to you.

We've scoured the team's collective brains and come up with no less than 41 tips and tricks to really max out your next build, or at least make you think about tidying up your current one. Whether you're a novice or a pro, a gamer or a 3D renderer, there's something for everyone in *Maximum PC*'s 2024 occasionally annual builder's manual.

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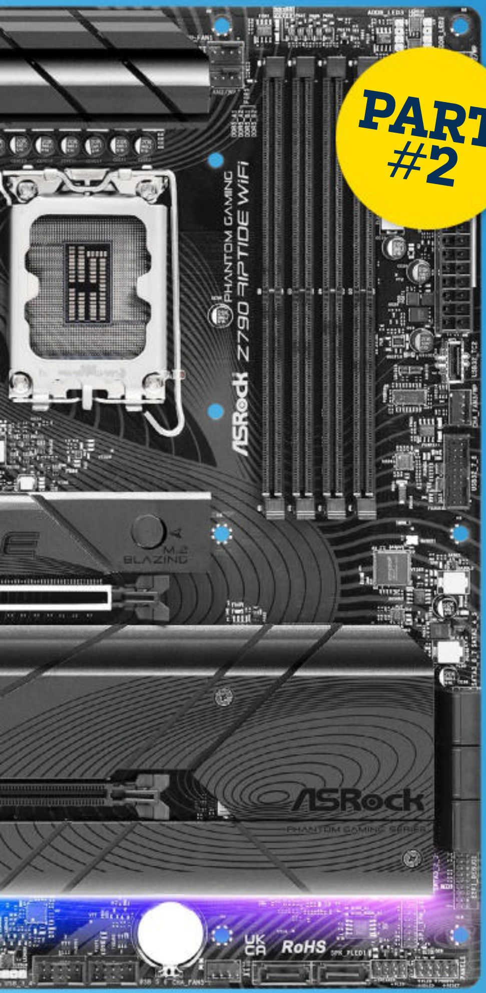
GIGABYTE



PART #2

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21 SSD OR SUPER-SLICK DOODADS

For modern M.2 SSDs, installation couldn't be simpler. Identify where your M.2 slots are, and remove any heatsinks in place (they'll likely have tiny screws, and be closest to your CPU, or below the PCIe slots on your motherboard). Then, similar to your RAM, locate the notch on the M.2 and the bump in the slot. Slide your M.2 stick in, being sure to secure it if there's any latch or screw mechanism there. Once done, replace the heatsink, making sure to remove the thermal pad film for maximum performance.

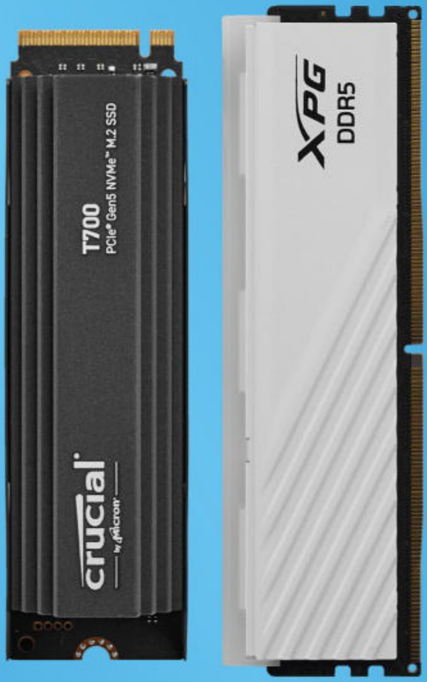
Also, ensure that you're installing your drive in the correct slot. Some M.2 slots will be PCIe 5.0 standard, while some may be 4.0, depending on the location and spec of your motherboard. Typically, the fastest M.2 slot will be the one closest to the CPU, and the slowest will be the one furthest away or on the back.

22 CUSTOM CABLING CONUNDRUMS

Cables can be tricky. Generally speaking, if you're installing a traditional modular power supply, always install your cables into the PSU prior to securing it into your case—it's just a little bit easier. Likewise, if you can get custom cables, definitely go for it—they add a hint of pizazz to any build, and if you really splash the cash, you can get custom-length ones to minimize cable management issues, too.

There are also a few neat tips and tricks we can recommend. If you're working in a budget or tight chassis, and your CPU cable isn't long enough, as long as it's well insulated, try running it between the motherboard and stand-offs. It might be a bit of a tight squeeze, but it can help to hide a messy cable. If you don't have cable management space, it will ensure that it's not trailing directly up through your build.

Another tip? Your front I/O. Do you need it? Outside of the power button, of course—we're talking USB ports and audio headers here. Honestly, we highly recommend them. If you don't intend to use them, you can simply bundle them up and shove them out of the way. Alternatively, when space is a luxury, as you'll see in some of our more premium liquid-cooled solutions, we actually cut out the redundant cables so we don't have to worry about them later. It's an extreme move, but every little helps.



23 HOW TO NOT KILL AN RTX 4000 SERIES CARD

Nvidia's 40 series cards (and technically the 3080 Ti) brought to the table a very particular cable that you might have heard of: the 12VHPWR600. It has a smaller footprint, can deliver more juice (600W), but has had a rocky start in life, with a number of cables burning up GPUs, catching fire, and everything in between. Some of this was down to poorly made adapters (with incomplete soldering, which Nvidia has recalled and rectified), but the majority of the problems actually arose from user error.

We always recommend avoiding the adapters where you can, and instead using a direct 12VHPWR600 cable from the PSU directly to the graphics card in question. Additionally, make sure that it is plugged in fully to your graphics card, and try to minimize any bend radius on it, too. Don't bend it up tight against a glass window pane or anything of that ilk, and you should be fine.

GEFORCE RTX

Avoid adapters unless you have to, and make sure the cable is plugged in.

24 DIAGNOSING FAULTS

So you've built your first PC. You hit the power switch, but nothing happens. What do we do now? Well, we go about diagnosing the fault. The best way to do that is via process of elimination.

There are a few key areas that trip up all PC builders from time to time—first and foremost are power switches. Check the wall and the back of the PSU, then make sure that the front panel header is on the right switch. If you're not sure, remove the front panel power cable, and use an insulated screwdriver to bridge the two power pins (a good indicator is if the motherboard's RGB or lighting turns on before all this).

At this point, if there's still no joy, we need to start checking the other components. Try reseating the memory, then the CPU. Check that the cables are installed and pushed in all the way. Also, reduce the tension on the CPU cooling block, then remove all the USB devices (a rogue flash drive can cause a non-start), and check that your motherboard has good contact with the standoffs. All of these are possible causes that can be remedied—machines can be fickle things at times.

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DELTA R
T-FORCE
DDR5 RGB

A lot of system boot errors occur because of memory and CPU installation.

25 HORIZONTAL OR VERTICAL GPU MOUNTING?

Which is best: horizontal or vertical graphics cards? Well, like a lot of these answers, it's going to depend on the chassis in question. GPUs can operate in effectively any orientation, as long as the cooling is sufficient as the card needs access to relatively cool air.

If you're running a triple fan cooler on an RTX 4080, and you slap it up vertically right up tight to a glass window, you're going to significantly impede the amount of air it can draw through those fans. That's going to lead to some toasty temperatures and a very hot window, neither of which we recommend. In those situations, it's more viable to go down the traditional route.

Don't worry about PCIe riser cables sucking up performance—according to our testing, there's no drawback whatsoever, although there is a cost element, as PCIe 4.0 cables aren't exactly cheap right now, sadly.

LINKUP's Ultra PCIe 4.0 x16 Riser cable is available in a number of lengths.

26 PREPARING YOUR BOOT USB

Ideally, you need to do this before you stop using your old rig, or on a laptop. But we're going to need to get a USB installer for Windows ready. You can grab an OEM key from G2A or Kinguin, but either way, the installation process will be the same.

Get yourself a 32GB USB stick (the faster, the better), plug it into a machine with a working Windows install, and head to microsoft.com/en-us/software-download/windows11. Once here, click the 'Download Now' button below 'Create Windows 11 Installation Media'. This will download an exe—run that, go through the process, making sure to select your removable USB stick, and let Windows prepare it for installation.

Once complete, we can do some extra prep to make our life a little easier. Go into the USB stick, and create two new folders: one called Drivers, and the other called BIOS. Windows won't read from either of these during the install process.

Then, go to your motherboard's product page, and make sure you download all the relevant drivers you need, particularly the Ethernet drivers and the CPU's chipset drivers. We highly recommend keeping it to drivers only. You can also pick up your Nvidia or AMD drivers for your GPU. While you're here, grab a copy of your latest BIOS file as well, and make sure that's extracted in the BIOS folder on your USB stick. With all this on board, you'll be ready to go.

27 THE TERRIFYING CASE OF THE BIOS UPDATE

Now comes the slightly scary part. BIOS updates are never fun. Boot up your new PC, making sure your USB stick is plugged in, and mash that delete key. This will vary depending on the mobo manufacturer, but there should be an EZ Flash or USB Flash, or some form of BIOS flash. Hit that, and your motherboard will go into a flashback mode. It'll ask you to select a BIOS file. Navigate to this, select it, and hit enter. The motherboard will then update your BIOS to the latest version.

There'll likely be a lot of restarts and random booting and flashing along the way. Be sure not to turn off the power or panic restart at any point, otherwise you could end up with a dead motherboard. That said, this is very important both to get the latest features, best performance, and solid stability, but also for security reasons.

28 INSTALLING WINDOWS WITHOUT INTERNET

With BIOS updated, change your boot order so it's now pointing at your USB Stick, and let your new shiny rig boot into the Windows installer. Then, let Windows install on your primary drive.

It may ask you for a software key—you can skip that. Eventually, you'll be asked to connect to a network (initially, it won't let you skip this). The thing is, some motherboards won't have Wi-Fi or Ethernet connectivity without the drivers installed. Once you get to the 'Let's connect you to a network' screen, press Shift + F10 on your keyboard to open up the command prompt, type 'OOBE/BYPASSNRO', and hit enter.

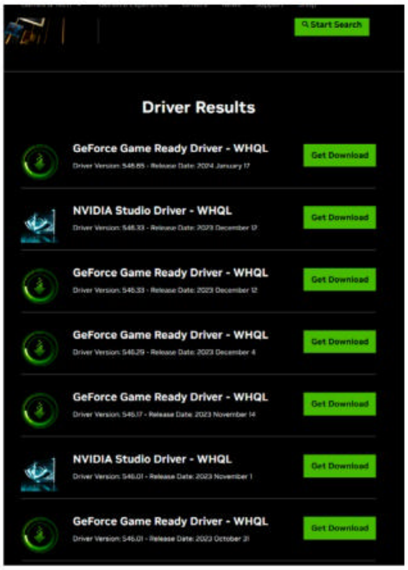
The Windows installer will now restart. Go through all the settings again, and once you land on the 'Let's connect' page, you'll see a 'I don't have the internet' link right next to the 'Next' button. Click that, then select 'Continue with limited setup'.

You'll then be able to set up an offline account, and get onto desktop. You can activate it on the desktop later, or by logging into your Microsoft account.

29 DRIVER INSTALL ORDER

This isn't necessarily a thing you need to follow, but once on desktop without internet access, it's a fantastic opportunity to install a ton of drivers and nip Window's Update's rampant installs in the bud before they get a chance.

We recommend installing in this order: CPU chipsets, Management Engines, Graphics Drivers, Audio, Bluetooth, WiFi



Driver Results

GeForce Game Ready Driver - WHQL
Driver Version: 546.65 - Release Date: 2024 January 17

NVIDIA Studio Driver - WHQL
Driver Version: 546.33 - Release Date: 2023 December 12

GeForce Game Ready Driver - WHQL
Driver Version: 546.33 - Release Date: 2023 December 12

GeForce Game Ready Driver - WHQL
Driver Version: 546.29 - Release Date: 2023 December 4

GeForce Game Ready Driver - WHQL
Driver Version: 546.17 - Release Date: 2023 November 14

NVIDIA Studio Driver - WHQL
Driver Version: 546.01 - Release Date: 2023 November 1

GeForce Game Ready Driver - WHQL
Driver Version: 546.01 - Release Date: 2023 October 31

No GeForce Experience? No problem—just keep an eye on driver updates.

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EXPLORE THE BEST LINUX & OPEN SOURCE SOFTWARE

From the best distros to system security, utilities and fun applications, we've rounded up everything you could ever need

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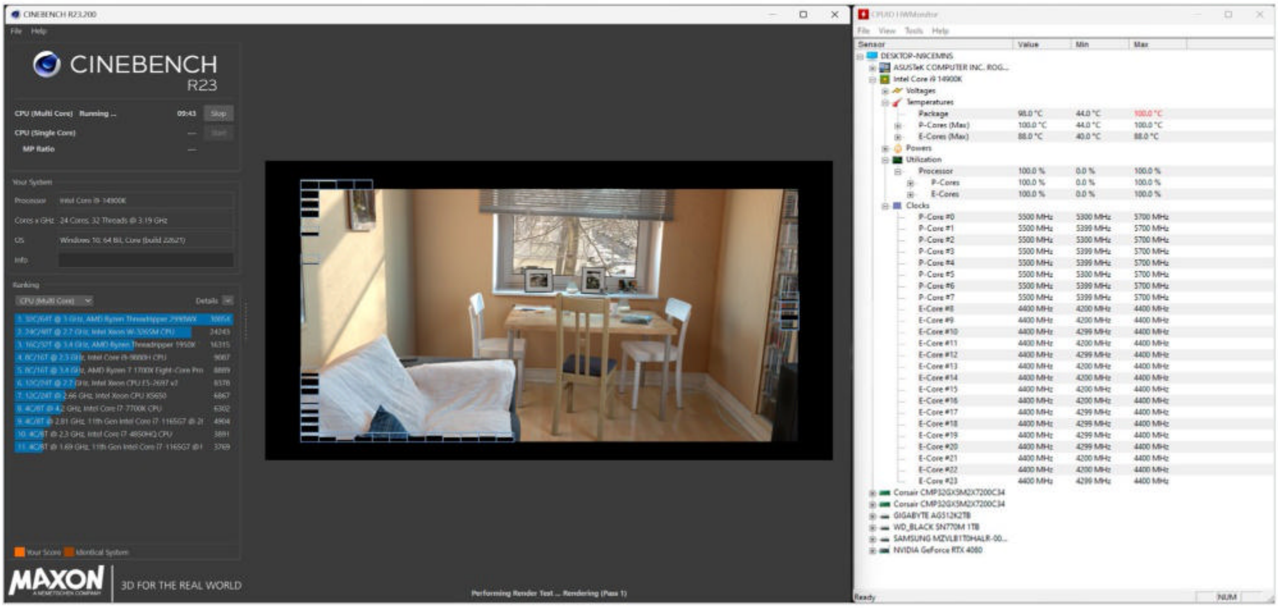


CPU (Multi Core) Running ... 09:43
CPU (Single Core) —
MP Ratio —

Your System
Processor Intel Core i9-14900K
Cores x GHz 24 Cores, 32 Threads @ 3.19 GHz
OS Windows 10, 64 Bit, Core (build 22621)
Info

Ranking
CPU (Multi Core) Details
1. 32C/64T @ 3 GHz, AMD Ryzen Threadripper 2990WX 30054
2. 24C/48T @ 2.7 GHz, Intel Xeon W-3265M CPU 24243
3. 16C/32T @ 3.4 GHz, AMD Ryzen Threadripper 1950X 16315
4. 8C/16T @ 2.3 GHz, Intel Core i9-9880H CPU 9087
5. 8C/16T @ 3.4 GHz, AMD Ryzen 7 1700X Eight-Core Pro 8889
6. 12C/24T @ 2.7 GHz, Intel Xeon CPU E5-2697 v2 8378
7. 12C/24T @ 2.66 GHz, Intel Xeon CPU X5650 6867
8. 4C/8T @ 4.2 GHz, Intel Core i7-7700K CPU 6302
9. 4C/8T @ 2.81 GHz, 11th Gen Intel Core i7-1165G7 @ 2(4904
10. 4C/8T @ 2.3 GHz, Intel Core i7-4850HQ CPU 3891
11. 4C/8T @ 1.69 GHz, 11th Gen Intel Core i7-1165G7 @1 3769

🟧 Your Score 🟧 Identical System

Performing Render Test ... Rendering (Pass 1)

Sensor	Value	Min	Max
DESKTOP-N9CEMNS			
ASUSTeK COMPUTER INC. ROG...			
Intel Core i9 14900K			
Voltages			
Temperatures			
Package	98.0 °C	44.0 °C	100.0 °C
P-Cores (Max)	100.0 °C	44.0 °C	100.0 °C
E-Cores (Max)	88.0 °C	40.0 °C	88.0 °C
Powers			
Utilization			
Processor	100.0 %	0.0 %	100.0 %
P-Cores	100.0 %	0.0 %	100.0 %
E-Cores	100.0 %	0.0 %	100.0 %
Clocks			
P-Core #0	5500 MHz	5300 MHz	5700 MHz
P-Core #1	5500 MHz	5399 MHz	5700 MHz
P-Core #2	5500 MHz	5300 MHz	5700 MHz
P-Core #3	5500 MHz	5399 MHz	5700 MHz
P-Core #4	5500 MHz	5399 MHz	5700 MHz
P-Core #5	5500 MHz	5300 MHz	5700 MHz
P-Core #6	5500 MHz	5399 MHz	5700 MHz
P-Core #7	5500 MHz	5399 MHz	5700 MHz
E-Core #8	4400 MHz	4200 MHz	4400 MHz
E-Core #9	4400 MHz	4200 MHz	4400 MHz
E-Core #10	4400 MHz	4299 MHz	4400 MHz
E-Core #11	4400 MHz	4200 MHz	4400 MHz
E-Core #12	4400 MHz	4299 MHz	4400 MHz
E-Core #13	4400 MHz	4200 MHz	4400 MHz
E-Core #14	4400 MHz	4200 MHz	4400 MHz
E-Core #15	4400 MHz	4200 MHz	4400 MHz
E-Core #16	4400 MHz	4200 MHz	4400 MHz
E-Core #17	4400 MHz	4299 MHz	4400 MHz
E-Core #18	4400 MHz	4299 MHz	4400 MHz
E-Core #19	4400 MHz	4299 MHz	4400 MHz
E-Core #20	4400 MHz	4299 MHz	4400 MHz
E-Core #21	4400 MHz	4200 MHz	4400 MHz
E-Core #22	4400 MHz	4200 MHz	4400 MHz
E-Core #23	4400 MHz	4299 MHz	4400 MHz
Corsair CMP32GX5M2X7200C34			
Corsair CMP32GX5M2X7200C34			
GIGABYTE AG512K2TB			
WD_BLACK SN770M 1TB			
SAMSUNG MZVL81T0HALR-00...			
NVIDIA GeForce RTX 4080			

Ready NUM

Cinebench is a surprisingly aggressive benchmark, particularly for your CPU.

and finally Ethernet. That way, you should have the latest CPU chipset and graphics driver, and Windows won't try to install one from six months ago first, forcing you to do a clean install immediately after.

30

NINITE NOW, NINITE FOREVER

Once all the drivers are in, you can really get the ball rolling. Ninite is still the king of initial install programs. Head to ninite.com and select the programs you want to install—browsers, messaging apps, game installers, Spotify, Notepad++, WinRAR, the lot.

While that's doing its thing, make sure you go into Settings, then Windows Updates, and check for updates. Even if Windows says you're up to date, sometimes it's just not checked properly. Make sure you've got all the latest updates and security patches. From there, install the programs you need. We'll leave that one for the pros, though.

31

OVERCLOCKING IN 2024?

Should you still be overclocking anything? Honestly, it's a tricky question. For us, it's just not worthwhile anymore. With temperatures being as high as they are, and turbo and smart frequency solutions as potent as they can be, keeping things stock and stable is as good a course as any. It's a similar situation for GPUs as well. You can, of course, bump up the power-target for your graphics card in MSI's Afterburner or similar software, but whether that's worth the extra temperature exuded is up for debate.

One thing you should make sure you have enabled is XMP, or AMD's EXPO memory profiles. Head to your BIOS and make sure your memory frequency is dialled in, particularly for Team Red, as that's where you'll get the most performance.

32

STRESS-TESTING YOUR PC

You've got a new PC, and everything's installed. Now, what can you do? We recommend stress-testing it, and running a few benchmarks. Generally speaking, these kind of operations are highly aggressive on the hardware, and not something we recommend for long periods of time, but if your system can handle these loads for any prolonged period, you can rest assured your PC will handle anything you can throw at it.

Pick up HWMonitor for system temperature monitoring. For CPU testing, we recommend either Maxxon's Cinebench R23, or Prime95. For GPU testing, something like Unigine's Superposition, or any of 3D Mark's gaming benchmarks, will fit the bill. You can run these on a loop to really stress out your rig. Of course, the best way to test its limits is to put it through its paces, doing what it was intended to do.

33

WHEN TO BUY

If you can, always buy your components during a sale period. Use tools like camelcamelcamel to check Amazon pricing on a part, and make sure what you're looking at is a good deal. Likewise, PCPartPicker has a pricing graph that will show you how that price has fluctuated over time. Black Friday and Prime Days are often the best time to buy, and most other ecommerce shops will likely be running similar sales.

On top of that, have a hunt around for other deals. Corsair, Western Digital, HyperX, and Asus often run sales throughout the year promoting one component category or another, so if you can find a good deal to take advantage of, definitely consider it.

34

BUYER'S REMORSE

This industry of ours is, let's be honest, horrendous. Every 6-12 months, there's a new top-tier graphics card, processor, motherboard, or cooling solution. It's the nature of the beast. No matter when you buy hardware, in a few months, something better will come along, and the price of your hardware will drop.

The thing is, that's okay. It's the price of progress that we pay, and if you wait around to buy the 'best' of anything in this industry, you'll be waiting forever, and never have a new PC. So try not to worry about it, relax, enjoy your shiny new PC, and go tinker with all those new Windows 11 desktop settings.

© CINEBENCH

Tools of the Trade Building a PC doesn't require much, but there are a few key parts we highly recommend to make it even easier

[35] CONTAINERS These are going to be your best friends. You can get a magnetic bowl—we highly recommend them, and they're remarkably cheap on Amazon. Alternatively, use a small glass, a ceramic bowl, a tupperware tub—literally anything with rounded edges will do the trick. The amount of case screws, side-panel widgets, mounting hardware, cable ties, and everything else in between that you'll accumulate and need during a build is horrendous.

noctua
DESIGNED IN AUSTRIA
NT-H1 10g
THERMAL PASTE

[36] THERMAL PASTE We've been recommending Noctua's NT-H1 paste for close to a decade at this point, and it's still our go-to thermal paste of choice, even compared to the NT-H2 that launched in 2020. Nope, the NT-H1 is cheap, performs well, has fantastic consistency, and keeps for a ridiculously long time. Most CPU coolers will come with a tube of paste or pre-applied thermal paste, but we highly recommend getting a tube of your own. Just make sure it's non-conductive. Plus, if you have a spare tube, they're super handy for repairing old graphics cards, or friends' PCs where the thermal paste may have cracked between whatever the CPU/GPU is and what's cooling it.

[37] OPTIONAL SPARE HARDWARE If you have hardware lying around from older builds that's compatible with what you're working on, it can be valuable. For instance, if you've got a Z790 board, but it hasn't been flashed ready for that new 14th gen chip, a 13th gen processor is useful. Likewise, memory kits for memory diagnosing, SSDs, or even power supplies can help you out, and make diagnosing system faults easier.

[38] CABLE TIES Grab a bag of these from Amazon on the cheap—you can pick up a pack of several hundred for less than $10, and they're well worth it for cable management. They can also act as emergency mounting solutions. We've secured graphics cards, fans, and SSDs using these things. You can also 'daisy-chain' them together to secure bigger blocks of cables, and most cases come with cable-tie mounts built in.

essentialresponse
99.9% ISOPROPYL ALCOHOL
100ml
DANGER

[39] ISOPROPYL ALCOHOL OR LIGHTER FLUID Placing highly flammable liquid on PC hardware might sound risky, but nothing cleans off the aforementioned paste better than either 99.99 percent proof alcohol or lighter fluid. Just dab a bit on a cloth or kitchen paper, and go to town cleaning up those CPUs. It's worth noting, however, that you do need to be careful with certain materials, as brushed aluminum and sandblasted finishes, vinyl, and plastics can react poorly if they come into contact with it.

[40] A GOOD SCREWDRIVER SET There's a number of manufacturers out there producing full-on kits for PC building, such as iFixIt, Linus Tech Tips, and Corsair, to name a few. Pick up a cheap set with as many bits as you can find, and you'll be able to install the largest of graphics cards to the smallest of M.2 screws. The reality, however, is that you'll likely only need a standard Phillips head-screwdriver for most of your work, and a smaller one for the M.2 heatsinks.

CENTERFOLD

PERFORMANCE GEAR LAID BARE

Nvidia GeForce RTX 4080 Super

LONG AGO, before the reign of the Supers, there was a graphics card. It was bold, gauche, and built with the blood of a Titan, with gaming in mind. Its heart was near identical to the goliath it was born from, yet it lacked the memory, spirit, absolute architectural majesty, and subsequent price tag of its Titanic kin.

Instead, this humble card was known simply as a Ti—Titanium, often with the number 80 before it. It was the ultimate gaming workhorse. It lacked the Tensor majesty and professional level technicality of its full-fledged, four-digit priced sibling, and instead gave us, the PC gamers, access to performance hitherto unseen before for a fraction of the price.

These two cards here, ladies and gentlemen, with their RTX 4080 Super beating hearts, are the spiritual successors to the Tis of old. They don't have the absolute monstrous transistor count, or the memory capacity of the 4090, but what they lack in developer drama, they make up for in gaming dominance at, finally, a sub-$1,000 price tag. **–ZAK STOREY**

GEFORCE RTX
REPU

1 AIB OR FOUNDER'S EDITION?

Asus, MSI, Gigabyte, Nvidia—the big four. All offer beautifully crisp designs for the RTX 4080 Super. Whether that's the stark white of an Asus Strix, or the deep milky black of a Founder's Edition, glimmering with a hint of white LED lighting, there's a GPU design for everyone.

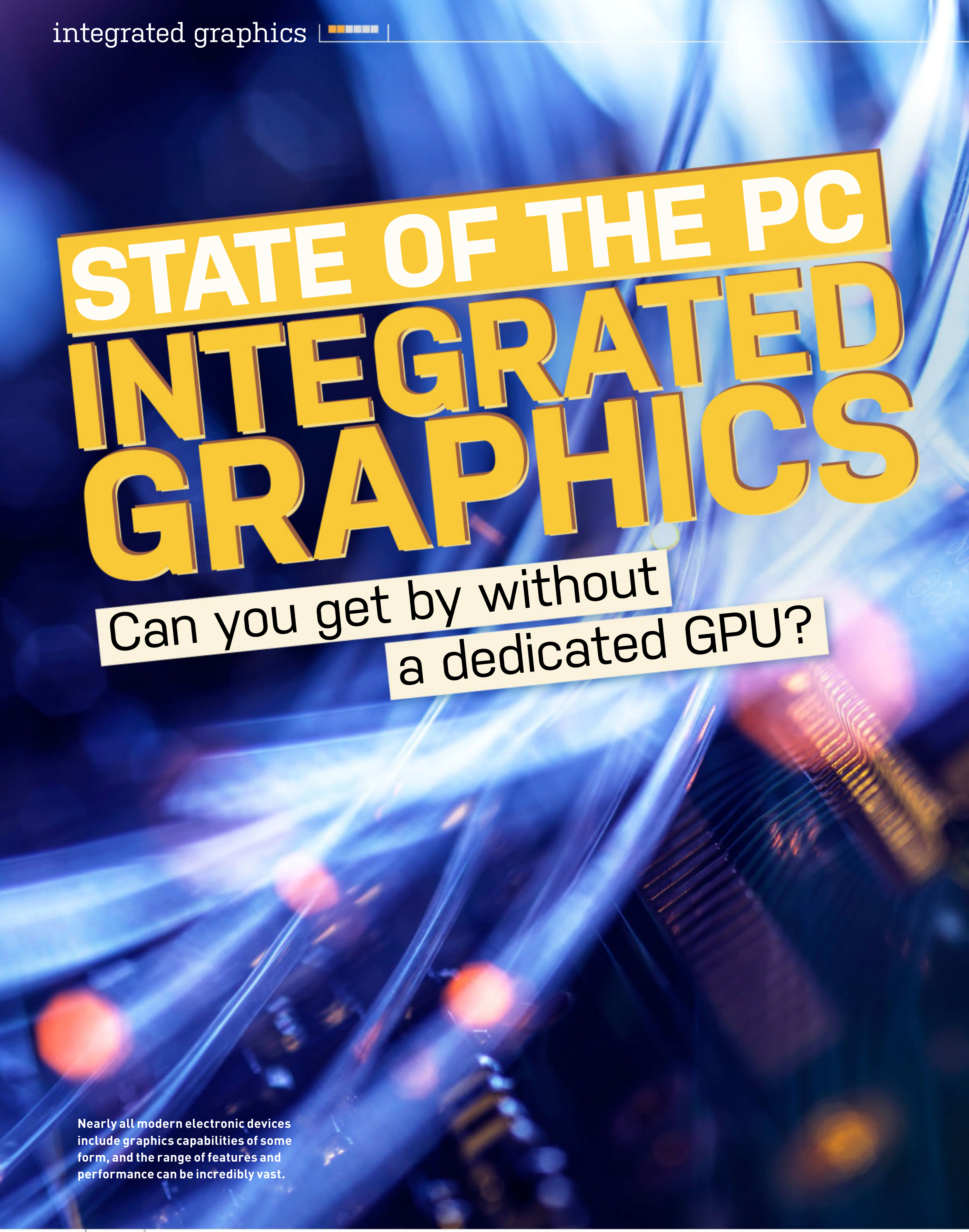
REPUBLIC OF GAMERS
RTX 4080 SUPER

2 MINOR UPDATES SMALLER PRICE

Don't be fooled; the RTX 4080 Super may only have a five percent hardware increase compared to the stock 4080, but what it lacks in hardware increase it makes up for with a $200 price drop.

3 4K MONSTER

Ever wanted to game at 4K 100fps in all of the latest titles, and then some? Well, with these beauties, you can absolutely do that. Across our testing, we've seen these GPUs smash through those triple digit 4K barriers with ease, and the 16GB of VRAM will be more than enough to keep you ticking for years to come.



STATE OF THE PC

INTEGRATED GRAPHICS

Can you get by without a dedicated GPU?

Nearly all modern electronic devices include graphics capabilities of some form, and the range of features and performance can be incredibly vast.

© GETTY IMAGES/ANDREW BROOKES

The PC has gone through a lot of changes, branching out in myriad ways and names. But whatever they're called, every computing device needs certain features: CPU, GPU, RAM, storage, the mainboard, and power. Take any one of those away, and the functionality plummets or fails. How much capability you need from each component varies by the intended use case.

Our focus for this state of the PC investigation will be on the GPU, specifically integrated graphics solutions. The GPU replaced the lesser video controllers of early PCs, which in turn replaced the punch cards of a bygone era. Whatever the name or complexity, the purpose is to output something useful.

Watches, phones, TVs, tablets, laptops, and desktops all have some form of display these days, with plenty of differentiation. For the PC, however, there are two categories of GPU: integrated graphics, which resides either in the same silicon as the CPU, or at least in the same package, and dedicated graphics. The integrated versions are usually lower power and performance, but are also basically 'free'—they come as part of the CPU.

These days, integrated GPUs can do just about everything you'd need, as far as typical computing goes. But how do they compare with dedicated GPUs, and how much have things improved over the past few generations? Let's dig deeper into integrated graphics.

A BRIEF HISTORY OF INTEGRATED GRAPHICS

Go back far enough into the history of PCs, and much of the functionality that is now part of the CPU used to be in a separate chip. Most desktop PCs prior to the late 90s had a dedicated graphics card—there were SVGA, VGA, EGA, and MCGA devices. But as technology advanced and Moore's Law allowed for increasingly large numbers of transistors to be packed into a chip, various elements were consolidated.

Our modern processors are effectively a system on a chip: nearly everything needed for main functionality is part of the CPU package. Memory controllers, cache, USB controllers, and graphics are now in a single die—what else are you going to do when you can cram over 25 billion transistors into a 250 mm2 chip? For reference, the entire 486 processor consisted of less than 2 million transistors in the late '80s and early '90s. That's over a thousandfold increase in about 35 years.

Before graphics processing was moved into the CPU package and die, it was first integrated into the chipset. Where today we normally have a single chipset for motherboards, we used to have two chips: the northbridge and southbridge. The northbridge housed the memory interface, which made it the ideal place to integrated graphics functionality, and that's what Intel did with its 810 chipset in 1999—that's officially generation one of Intel Graphics, if you're wondering.

Over the proceeding years, the dual chipsets merged into a 'platform controller hub' chip, the memory controller moved into the CPU, and graphics shifted to the CPU as well. But even then, there were different levels of integrated graphics within the same generation. Intel currently has laptop chips that come with up to 1,024 GPU shaders, while its desktop chips only have 128 or up to 256 shaders—and they're not even the same base level of functionality.

The AMD side of things is different in some ways, but there's still a gap between what level of integrated graphics you can get. Today's Ryzen 7000-series processors all include basic functionality graphics that can run a monitor and play videos, but these only have two of AMD's Compute Units, with 64 GPU shaders per CU (128 shaders total). The new Ryzen 8000G processors, meanwhile, come with up to 12 CUs and 768 shaders, plus higher clocks on the GPU, providing potentially up to 10 times the performance.

The previous generation iGPUs on both AMD and Intel were quite a bit slower, with up to eight CUs on AMD and 768 shaders on Intel—33 percent and 25 percent fewer ALUs respectively, each less capable than the latest versions. And those were the best options, with lesser chips trimming down shader counts and performance.

To put things in perspective, modern desktop GPUs from AMD feature up to 96 CUs in the RX 7900 XTX—eight times as many as its fastest integrated GPU. Intel now offers dedicated GPU solutions, with the Arc A770 providing four times as many shaders as its top integrated solution. That's a massive gap in potential performance, but also in power requirements. The 7900 XTX can suck up 355W of power, while the Ryzen 7 8700G is rated for just 65W. Mobile variants like the Ryzen 7 8740U consume just 28W.

DESKTOP INTEGRATED GRAPHICS PERFORMANCE

As Intel doesn't offer a compelling desktop iGPU solution, we're looking at AMD's fastest current and previous generation APUs, and we've included an inexpensive Core i3-13100 processor paired with a GeForce GTX 1650 GDDR6 dedicated GPU for comparison. Note that the price of the i3-13100 plus GTX 1650 roughly matches the cost of the Ryzen 7 8700G at around $329 (see our full review on page 78).

All eight games that we tested used low settings, though what that means in practice varies by game. *Cyberpunk 2077*, even at the lowest settings possible, still ends up with far more complex graphics than any other game, for example, and this is reflected in its lower performance. It was the only game where both the 8700G and GTX 1650 failed to average over 60 fps at 1080p.

Nearly all the games ended up running best on the low-end Intel CPU with a dedicated Nvidia GPU, even though the GTX 1650 represents a budget solution from five years ago. That's a pretty poor showing from the integrated graphics solutions, but there are other factors in play.

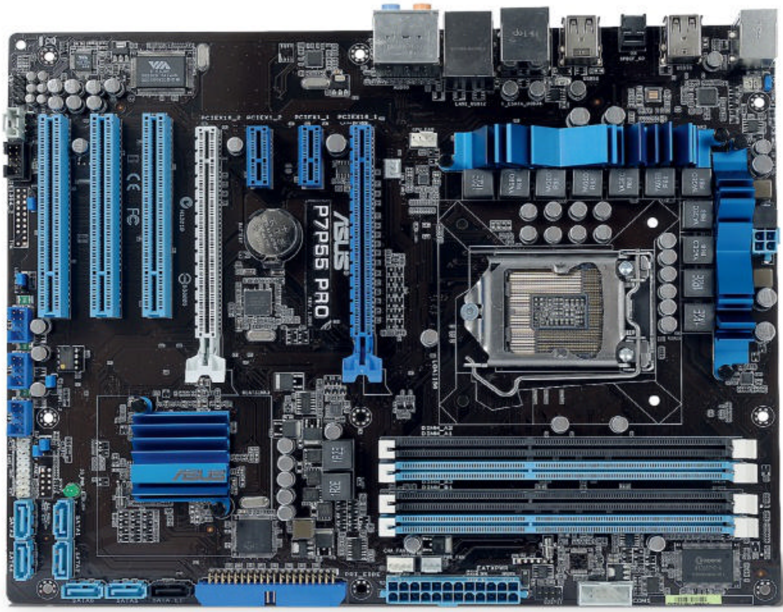
Perhaps most important is that the two Ryzen processors each have a total power budget of just 65W. The Core i3-13100 is a 60W processor, but the GTX 1650 has its own 75W pool of power to draw from. That's over twice the available power for the CPU plus dedicated graphics, in other words, and that certainly helps with performance.

The integrated GPUs also share memory bandwidth with the CPU, and

BENCHMARKS

Game	Ryzen 7 8700G	Ryzen 7 5700G	i3-13100 + GTX 1650
8 Game Average (Geomean)	129 / 89	78 / 49	**159 / 113**
Borderlands 3	97 / 68	63 / 37	**123 / 92**
Cyberpunk 2077	75 / 44	34 / 26	**79 / 50**
DOTA 2	**214 / 183**	180 / 157	174 / 169
F1 2023	178 / 116	91 / 52	**252 / 160**
Far Cry 6	115 / **90**	52 / 28	**126** / 81
Grand Theft Auto V	168 / 135	139 / 85	**180 / 179**
Shadow of the Tomb Raider	103 / 69	59 / 38	**151 / 101**
Strange Brigade	142 / 76	92 / 49	**275 / 149**

Best scores in bold. Testing was conducted using 2x8GB of memory, with DDR5-5600 on 8700G and Core i3-13100, or DDR4-3200 on 5700G. Scores shown are average FPS at 1280x720 / 1920x1080 at low settings.



Socket LGA1165 with support for Intel 'Clarkdale' processors was the first time Intel included graphics on the same die as the CPU.

AMD's previous generation chip incurs a stiff penalty because it only has DDR4 memory. Some games clearly want more memory bandwidth, while others don't appear to be bothered as much. There are also differences in GPU architectures, with the 8700G leveraging RDNA 3, while the 5700G drops back to the three generations-old Vega architecture. Nvidia's GTX 1650, meanwhile, uses the two generations-old Turing architecture.

CPU performance mostly doesn't seem to be a major factor in gaming performance, with the exception of the oldest game in our test suite: *DOTA 2*. The low settings are light enough that CPU limits come into play, with the 8-core Zen 4-based 8700G taking a lead over the 4-core 13100 in DOTA 2. The 8700G also claimed victory in *Far Cry 6* at 1080p, likely helped by its newer GPU architecture.

While the results might look rather poor for integrated GPUs, it's important to

INTEL METEOR LAKE & ARC GRAPHICS

For desktop integrated graphics, there's really no competition between AMD and Intel. Intel's graphics solutions in 12th through 14th Gen Core processors use the same Xe-LP architecture as the 11th Gen Tiger Lake laptop processors that launched in 2020, except where the mobile chips included Xe Graphics with up to 96 graphics Execution Units (768 shader ALUs), the desktop processors top out at just 32 EUs (256 shaders).

That makes for a huge gap in potential performance. Where the older mobile GPUs could deliver up to 2.1 teraflops of compute, even the fastest desktop iGPUs from Intel still fail to break the 1 teraflop barrier: the Core i9-14900K with UHD Graphics 770 offers a theoretical 845 gigaflops of graphics compute. They're sufficient for basic office and desktop use, with decent video decoding and encoding capabilities, but for gaming and graphics they're only fit for very lightweight tasks—stuff from around a decade ago should be okay.

Intel does much better with laptop graphics. The Arc Graphics in the latest Core Ultra processors peaks at a theoretical 4.8 teraflops. That should prove more than capable of competing with previous generation budget GPUs, and on paper at least it's roughly equal to Nvidia's old GTX 1650 Super. However, it has to share system memory bandwidth and power with the CPU, and drivers appear to be holding Arc Graphics back—a bit like the first few months of Arc dedicated GPUs has been our experience.

Will Intel 'go big' on desktop integrated graphics? We suspect not, because the easiest way to boost graphics performance in that case is to add a dedicated graphics card. Laptops benefit from the power savings with integrated graphics, which for desktops Intel already offers dedicated Arc solutions.

ASUS Zenbook

Intel's latest Meteor Lake processors integrate Arc Graphics, but they're only for laptops, and we'll need to wait for Arrow Lake to get desktop alternatives.

note that AMD's latest solution offers good overall performance for an entry-level part. It's not going to go head-to-head with the latest dedicated desktop GPUs, but that's not the point. It's a relatively inexpensive and power-efficient solution with enough horsepower to manage most modern games—at least if you turn the settings and resolution down far enough.

IT ALL DEPENDS ON YOUR NEEDS

We have now reached the stage where virtually every new processor going forward will come with integrated graphics that deliver at least baseline functionality for running Windows. AMD's Ryzen processors didn't include graphics for most models prior to Zen 4 and the Ryzen 7000-series, but advancements in manufacturing processes mean the cost of including a basic GPU are small enough that it's worth doing—even if it's not utilized by many people.

Desktop gaming PCs and custom-built DIY systems will almost always find reasons to include a graphics card, but they're a relative minority of new PCs these days. One of Intel's advantages

AMD HYPR-RX

We normally test using native resolution benchmarks, but for integrated graphics solutions, it can be beneficial to look at other tweaks that can boost performance. AMD HYPR-RX provides a quick way to boost performance across virtually every game, albeit with some quirks.

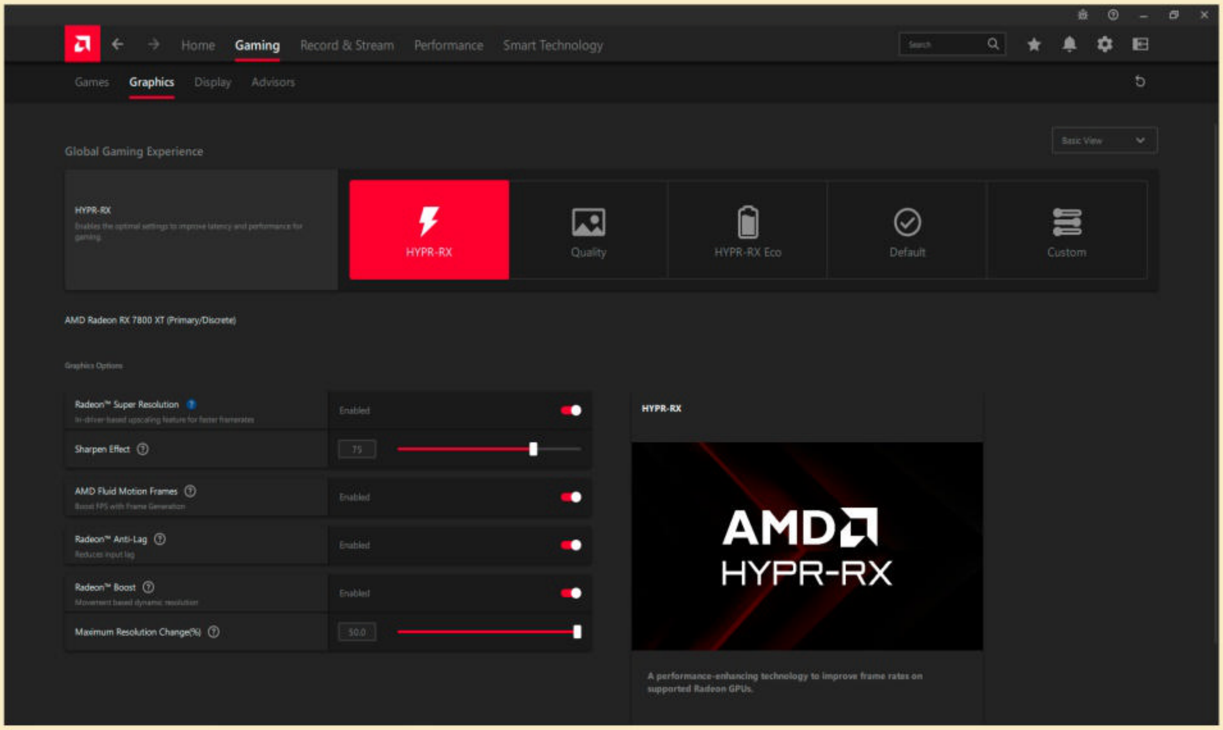
HYPR-RX enables four AMD features: Radeon Super Resolution (RSR), AMD Fluid Motion Frames (AFMF), Radeon Boost, and Radeon Anti-Lag. Anti-Lag is the only feature that shouldn't reduce image quality, as it reduces the latency between when a frame finishes rendering and when it shows up on the monitor. The other three are a different matter.

RSR uses driver-level spatial upscaling. It's basically FSR 1.0 (FidelityFX Super Resolution), except it doesn't require game developers to integrate support. RSR can cause some noticeable artifacts, particularly at lower resolutions, but rendering fewer pixels and then doing a fast upscale will certainly improve performance.

AFMF also uses driver-level enhancements that should work with most games, but instead of upscaling, it does frame generation. Frame generation doesn't usually improve the feel and responsiveness of games, instead functioning as a form of frame smoothing. AFMF works best with games where you already have a high frame rate; in games running at closer to 30 fps, our experience so far is that it can often cause stuttering and frame pacing problems.

Like RSR, Radeon Boost also attempts to reduce the number of pixels rendered by rendering at a lower resolution. Instead of upscaling, it alters render resolution based on player movement. The idea is that with fast motion—ie. turning rapidly—fine details aren't perceptible, and it's more beneficial to increase frame rates and responsiveness by lowering (by up to 50 percent) the render resolution. Unlike RSR and AFMF, Radeon Boost is only supported in a limited number of games—28 at the time of writing.

Is HYPR-RX good? We feel it's more of a mixed experience, but if you're interested in getting higher FPS, regardless of whether it impacts visual quality, give it a shot. Alternatively, you can tweak games to only enable some of these features, which is less likely to create issues, in our experience.



Global Gaming Experience

HYPR-RX
Enables the optimal settings to improve latency and performance for gaming.

AMD Radeon RX 7800 XT (Primary/Discrete)

Graphics Options

Radeon™ Super Resolution — Enabled
In-driver based upscaling feature for faster framerates
Sharpen Effect — 75
AMD Fluid Motion Frames — Enabled
Boost FPS with Frame Generation
Radeon™ Anti-Lag — Enabled
Reduces input lag
Radeon™ Boost — Enabled
Movement based dynamic resolution
Maximum Resolution Change(%) — 50.0

HYPR-RX
A performance-enhancing technology to improve frame rates on supported Radeon GPUs.

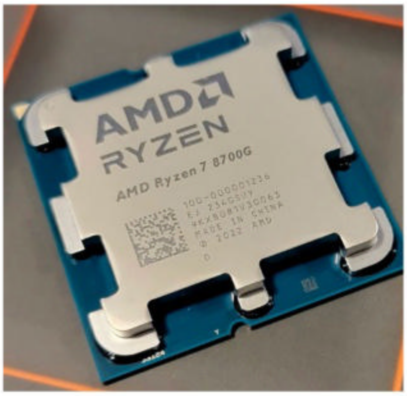
AMD HYPR-RX promises a one-stop boost to graphics performance by enabling a bunch of AMD technologies, though beware it can greatly impact overall image fidelity.

© AMD

over AMD since the advent of Ryzen CPUs in 2017 has been that virtually every Intel processor has included graphics functionality. That's a huge benefit both for laptops and business PCs, which is why AMD needed to address that deficiency.

The majority of PCs sold today are laptops, and integrating graphics into the processor can greatly improve battery life. Every additional chip means more traces and higher power requirements, which can also greatly increase the overall cost—it's not just the GPU, but also the VRAM that dedicated chips require. Even with relatively weak iGPUs, Intel previously dominated the mobile landscape. AMD's more recent mobile chips, starting with the 4000-series, greatly improved graphics performance and battery life, and gained a lot more traction as a result.

Outside of gaming, the modern reality is that most people don't even need more than a modest iGPU. Accelerated video decoding became standard fare on Intel GPUs in 2010, and performance and features have improved substantially since then. Our modern iGPUs now offer up to 100X the theoretical performance of Intel's original HD Graphics, and what was once barely adequate for basic tasks has become sufficient for nearly any common task short of higher resolution gaming or professional video work.


AMD's Ryzen 7 8700G targets a very particular niche for desktop users.

It's not just gaming, of course. AI is the latest buzzword, and Intel is now pushing the 'AI PC', specifically talking about its latest Meteor Lake laptops. But with graphics that are fast enough for most work, putting in a larger GPU to handle AI workloads would be overkill, not to mention hurting battery life. The solution is to instead include an NPU, Neural Processing Unit, that's designed for power efficiency while delivering enough performance to meet the requirements of tools like Microsoft's Copilot. AMD also has an NPU in its latest mobile processors, and Apple and Samsung have been including NPUs in their processors for a few years now as well.

Integrated graphics will continue to improve each generation, and there's still potential for future applications to benefit more from faster GPUs. Apple, as a counter example, has increased its iGPUs over the past few years, but that's mostly for Pro and Ultra variants, with the base model M2 relatively comparable to a Radeon 780M in compute potential. Apple isn't being as forthcoming with details about the new M3 other than that it now supports mesh shaders and ray tracing (like the 780M, incidentally).

Ultimately, whether a particular iGPU will suffice comes down to how you intend to use your PC. With desktops, it's relatively trivial to buy a dedicated graphics card and add that to your system. Laptops aren't as flexible, which is also why the chips tend to have a higher level of iGPU performance. The good news is that the latest mobile iGPUs are potent enough to satisfy the needs of most people, up to and including even moderate gaming.

CONSOLE GRAPHICS

Could AMD or Intel make a substantially faster integrated graphics solution than what we've seen so far? Absolutely! The difficulty isn't with making such a chip, but rather finding a target market for the chip as well as turning a profit. A great case in point are consoles, which have comparatively massive iGPU solutions.

The Xbox Series X has the largest integrated GPU at present, with 52 AMD RDNA 2 Compute Units and 12.1 teraflops of compute. The PlayStation 5 isn't too far behind, with 36 RDNA 2 Compute Units and 10.3 teraflops. That's about two to three times the potential performance of the Radeon 780M used in the Ryzen 7 8700G.

It's not just about raw computational power either. The Xbox GPU has access to 10GB of GDDR6 memory on a 320-bit interface, with 560 GB/s of dedicated bandwidth. The PS5 GPU shares 16GB of unified memory with the CPU, using a 256-bit interface with 448 GB/s of bandwidth. A desktop with a dual-channel DDR5-6400 memory configuration by comparison has a 128-bit interface and only 102.4 GB/s of bandwidth.

So why doesn't AMD create a similar solution for desktop PCs? It's a matter of economies of scale and flexibility. An Xbox Series X sells for just $479, and includes specs that would make a similarly priced PC weep with envy. There are two things that allow consoles to hit such competitive prices. First are the economies of scale: tens of millions of Xbox Series X and PS5 consoles have been sold, which allows margins on each console to be smaller. Second, the console price can be offset by expected income from game sales.

Sure, outside of storage, you can't upgrade anything on a console. But there's a big benefit in having a static platform, as game developers know exactly what hardware their games need to run on.

The fastest integrated graphics solution around right now is in Microsoft's Xbox Series X console, with performance roughly matching an RX 6700 desktop GPU.

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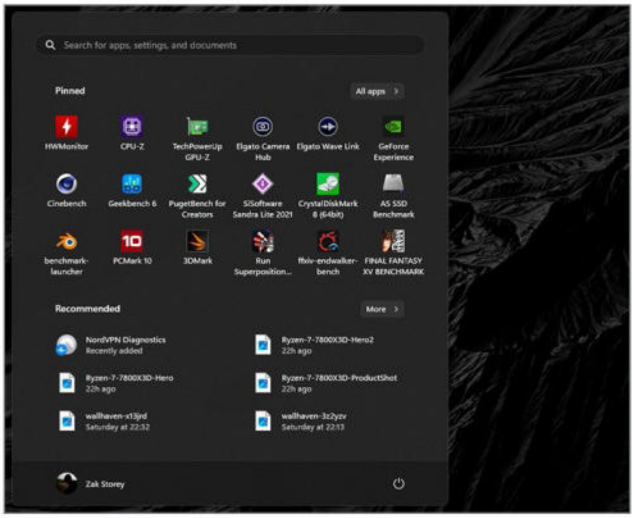
HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

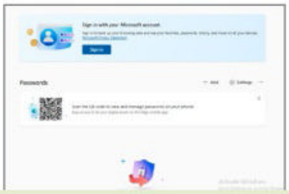
TIP OF THE MONTH


Search for apps, settings, and documents
Pinned
All apps
HWMonitor
CPU-Z
TechPowerUp GPU-Z
Elgato Camera Hub
Elgato Wave Link
GeForce Experience
Cinebench
Geekbench 6
PugetBench for Creators
SiSoftware Sandra Lite 2021
CrystalDiskMark 8 (64bit)
AS SSD Benchmark
benchmark-launcher
PCMark 10
3DMark
Run Superposition...
ffxiv-endwalker-bench
FINAL FANTASY XV BENCHMARK
Recommended
More
NordVPN Diagnostics
Recently added
Ryzen-7-7800X3D-Hero2
22h ago
Ryzen-7-7800X3D-Hero
22h ago
Ryzen-7-7800X3D-ProductShot
22h ago
wallhaven-x13jrd
Saturday at 22:32
wallhaven-3z2yzv
Saturday at 22:13
Zak Storey

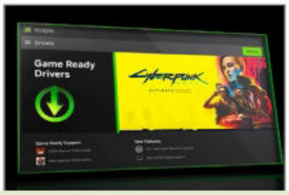
DON'T UNDERESTIMATE THE START MENU

Less of a tip and more general advice: how many of us have sat there with a blank or default start menu in Windows 11? Take advantage of it. Right-click and remove the default junk programs Microsoft loads on there by default, and pin genuinely useful—but less used—apps that you need on a weekly basis. It'll keep your desktop tidy, and your taskbar shiny.

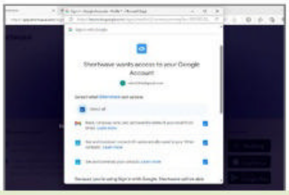
MAKE – USE – CREATE



62
Open-source password managers



66
Control your settings with the Nvidia app



68
Have your own AI executive assistant

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ZAK STOREY
CONTRIBUTOR

TIME AND TIME AGAIN

Life is busy at the moment. The freelance life is fun, but I've paired it with working full-time as a barista in a local independent coffee shop, as I love coffee and needed a bit of social interaction after leaving my last working-from-home job. I'm actually a director of a limited company with the shop, too, working on coffee media content for their site.

It's long hours and longer days. I work in the shop five days a week, typically on shift from 6:30am to 3:30pm. From 4:30 to 11pm, I'm working on freelance content. My two other 'days off' are spent on either more freelance, or a bit of archery.

I spend the moments I steal away for myself downstairs with the spouse, her buried in one of her books, and myself, gaming on the PS5. Yeah, I know. Sony's Playstation Plus subscription service has been a blessing.

I don't know what it is, but paying $15 a month is just so palatable to me. Being able to jump in and out of games quickly, rather than dropping cash on a title I'm not sure I'll like, is better.

I'm not giving up PC gaming entirely, however. *Elden Ring*'s DLC trailer just dropped, and *World of Warcraft* is going to suck me back in with the next expansion, although I might have to use my vacation days to play.

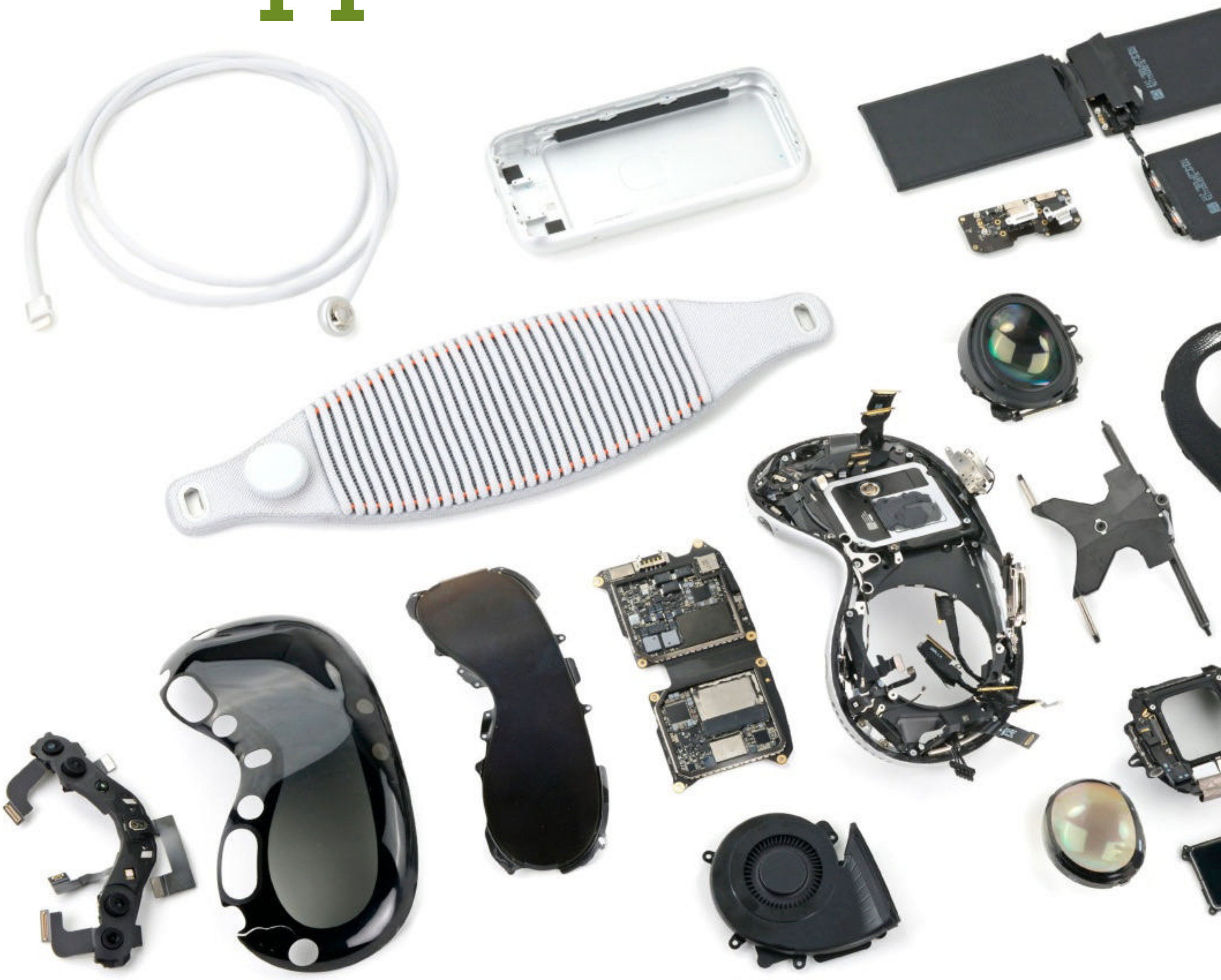
↘ submit your How To project idea to: editor@maximumpc.com

IFIXIT
presents:

AUTOPSY

THIS MONTH WE DISSECT...

Apple Vision Pro



About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com

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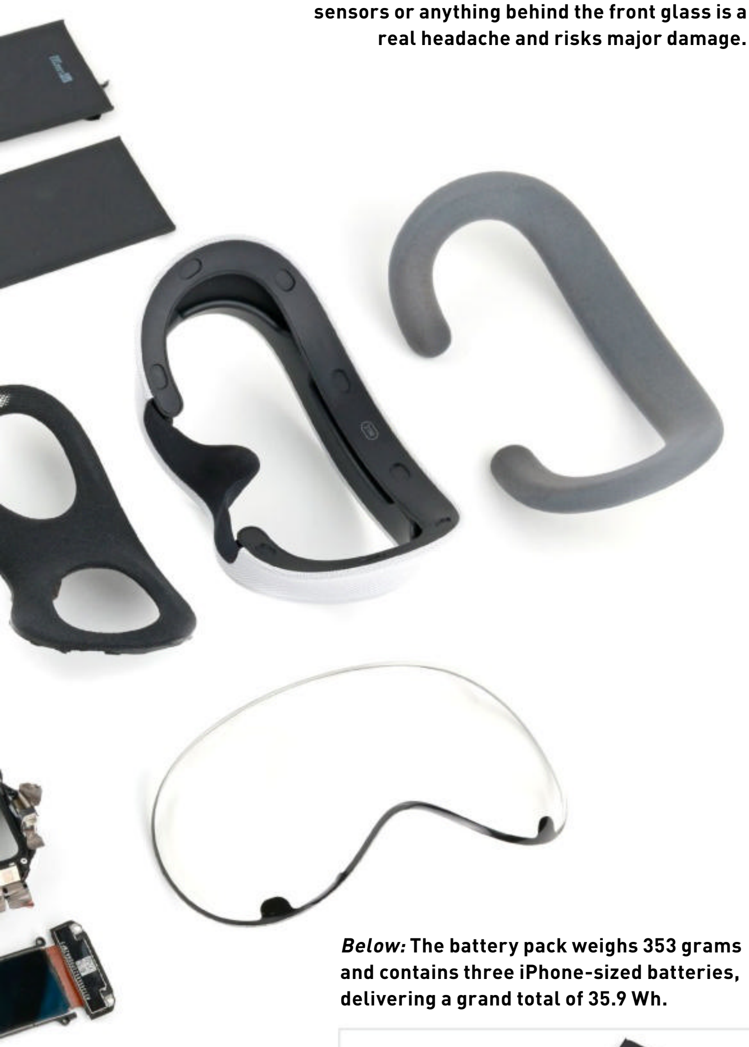
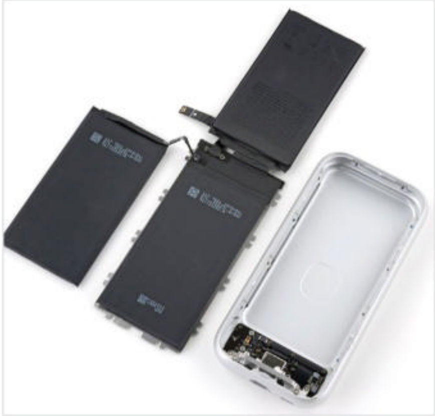
While the Vision Pro does offer some modularity, getting to the front cameras and sensors or anything behind the front glass is a real headache and risks major damage.



Below: **The battery pack weighs 353 grams and contains three iPhone-sized batteries, delivering a grand total of 35.9 Wh.**



Far left: **The glass panel is glued on. It didn't break, but its protective plastic film got a little peeled up and a bit melted.**

Left: **The front Eyesight display has a lenticular layer on the exterior OLED panel. VisionOS renders multiple images to create a 3D effect.**

BACKGROUND

What's the strangest thing about the Vision Pro? It's that bubble glass front displaying a 3D-ish video of the user's eyes. But what does it do to the headset's repairability?

MAJOR TECH SPECS

- Dual micro-OLED displays with 23 million pixels and 100Hz refresh
- Apple M2 SoC with eight-core CPU and 10-core GPU
- Apple R1 image processing chip
- 3D stereoscopic camera system, dual 6.5MP
- Six world-tracking cameras, four eye-tracking cameras, LiDAR, light sensor
- Spatial audio with head tracking
- External lenticular OLED Eyesight display
- External battery pack
- VisionOS

KEY FINDINGS

- The glass panel is glued on, of course, and it took a lot of heat and time, but we removed it without breakage. Granted, it didn't come out unscathed—the glass has a protective plastic film that got a little peeled up and maybe a bit melted. Apple's retail fixers might have faster hands than us, but they'll charge you $799 to replace broken front glass.

- The speakers are fixed onto the two rigid bands that join to the main headset. To release these, use the SIM card removal tool. The holes are inside the temples of the main headset, and the removable bands have a row of electrical contacts, like Lighting connectors. This gives us hope that opening the headset may not be as daunting as we assumed.

- The battery pack alone weighs 353 grams and is made of three iPhone-sized batteries, delivering a grand total of 35.9 Wh—more than double an iPhone 15 Pro's 17.3 Wh. The cells themselves are 184g apiece, surprisingly only about half the weight of the full battery pack. To get inside, we had to soften some perimeter adhesive and release a set of single-use metal clips, then twist open Torx screws galore.

- Every face is different, and Apple is selling 28 light-seal parts to cover all the different face sizes and shapes. The seals attach to the main headset using magnets, which is Apple through and through—it's either glued in place, or extremely easy to swap. This modularity is a brute force attempt to get an ideal fit on your face. It will be interesting to see if this is required long term, or if future devices find a simpler way to accomplish this.

- Under the magnetic seals is a permanent seal, also wrapped in a knit fabric, but less likely to get smudged. It also happens to be the way into the interior of the headset. Removing it reveals another surprise: a thin, stretchy sheet of plastic. Whether it's to compensate for gaps in the knit, or keep particulates out of the innner workings, we're not sure. But we are certain this bit looks very 'masked superhero'.

- The Vision Pro has a lenticular layer on top of the exterior OLED panel. VisionOS renders multiple face images—call them A and B—slices them up, and displays A from one angle serving your left eye, and B from another serving your right eye. This creates a 3D face via the stereoscopic effect.

- Repairability Score: 4 out of 10 (10 is easiest to repair). On one hand, there's a lot to like. The battery is modular, as are the side straps with integrated speakers. We also like the easy-to-fit lens inserts and magnetically attached light shields. On the other, getting to the front cameras and sensors is tricky. The glass cover needs a lot of finessing, and cracking it might render the sensors useless.

Use an open-source password manager

YOU'LL NEED THIS

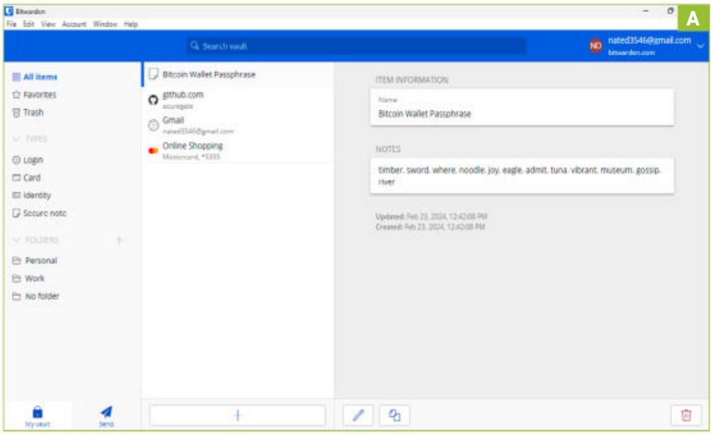
A COMPATIBLE WEB BROWSER
Administrative rights to set up the password manager

IN LATE 2023, cybersecurity blogger Brian Krebs reported on the November 2022 breach of LastPass' database, wherein the password vaults of 25 million users were stolen. Citing a recent spate of cryptocurrency thefts to the value of $35 million from security-conscious people in the tech industry, Krebs speculated that at least some of LastPass' vaults were cracked.

It's hard to tell if this is true, as like many password management platforms, LastPass isn't fully open-source. Proprietary software can't be subjected to public scrutiny, so it's difficult to verify claims like 'zero knowledge encryption' server-side. Open-source software is built on the philosophy that 'many eyes make bugs shallow', making it the gold standard for privacy.

In this guide, we've focused on three of the very best open-source password managers. By making the source code freely available, the developers are providing the best assurance that the software lives up to its claims. We'll also focus on what KDFs (key derivation functions) are used, along with which encryption algorithms are deployed for savings sensitive data.

You'll also glean tips on creating a strong, memorable master passphrase, and learn why you really can't rely on your browser's built-in password manager. **–NATHAN JORDAN**



Name
Bitcoin Wallet Passphrase

NOTES
timber. sword. where. noodle. joy. eagle. admit. tuna. vibrant. museum. gossip. river

© BITWARDEN

1 BITWARDEN

First release: 2016
Supported OS: Linux, macOS, Windows
Browser extension: Chrome, Firefox, Safari, Edge, Opera, Vivaldi, Arc, Brave, Tor
Mobile version: Yes (Android & iOS)
Available in Microsoft Store: Yes

Bitwarden uses an open-source codebase, and all core functions are available for up to two users free of charge. The developers actually take their open-source credentials seriously, making all code available via GitHub. They also submit to regular security audits and offer a bug bounty program.

» This means that when Bitwarden claims that all user credentials are protected by zero-knowledge end-to-end encryption, it's easy to take these claims at face value. Upon first registration, users are asked to create a 'Master Password' of at least 12 characters [Image A]. Bitwarden then works client-side with PBKDF2 or Argon2 to stretch the master password using the user's email as a salt to create a 256-Bit master key.

» Neither this master key nor the original password are ever stored on Bitwarden's servers, meaning that even if a hacker were to breach them, they'd still have to crack your data, which is secured with AES-CBC 256 bit encryption.

» The downside to this, naturally, is that if you lose your master key, there's normally no way to access your credentials, which is why some Bitwarden Enterprise tiers do allow user account recovery.

» By default, the platform stores your data in the cloud via Microsoft Azure, though for the ultra paranoid self-hosted solutions are available.

» After signing up, you can install the desktop client for your OS of choice, as well as the mobile version available for both Android and iOS—there's no proscribed limit to the number of devices you can sync to your account.

» Bitwarden also offers a browser extension for virtually all platforms. During our tests, we initially weren't able to get it to prompt us to save passwords until we opened it and actually signed in using the master key.

» Once you do this, Bitwarden will prompt you to save login credentials for all accounts each time you sign in. If you choose to create a new account, a 'New Item' option will appear when you click on the password field. From here, a pop-up will appear, prompting you for a username and password.

» Bitwarden can also automatically generate a new random passphrase. Special mention should go to Bitwarden's password generator, which can not only create strings of random characters, but actual passphrases made of random words (and optionally numbers). When creating a password, you can also have Bitwarden avoid ambiguous characters like 0 and O.

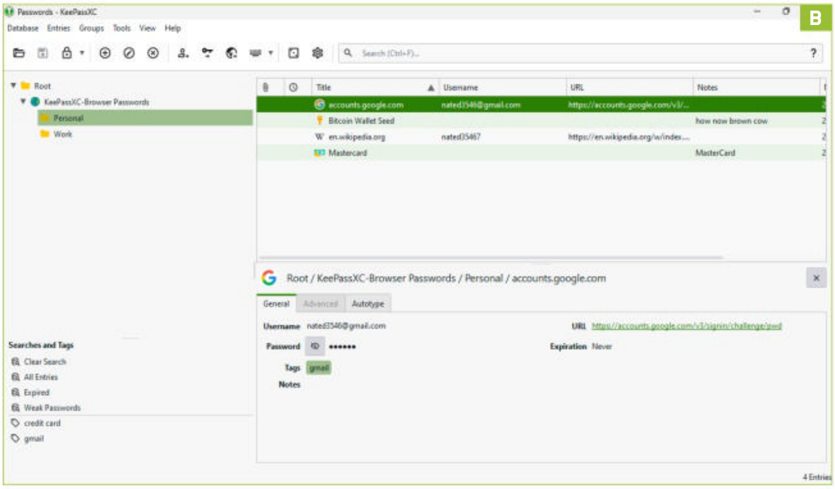
» Whether you log in via the web portal or the desktop client, the interface is virtually identical. Still, its spartan look belies the fact that even free users benefit from a huge number of features.

» Starting in the left-hand pane, you'll see by default that Bitwarden lists 'All Items'. You can filter these easily by clicking into various 'Types': Login covers any online accounts whose credentials you've saved while browsing.

» The 'Card' and 'Identity' categories can be used to store credit card and ID information respectively. We were especially impressed by the 'Secure Note' feature, which you can use to store any other sensitive information that doesn't fall into these categories, like a Bitcoin wallet seed. When creating new credentials, you can also have Bitwarden prompt for the master key in order to display them again.

» If you want to delineate your life further, you can also use the client to create custom folders such as 'Work' and 'Personal', then place existing/new credentials there.

» All of the above should provide everything you need in a password manager, but if you want to shell out an extra $10 per year, you can receive extra perks. For instance, while Bitwarden supports 2FA (two-factor authentication) login via regular authenticator apps, Premium users can use proprietary options like YubiKey and Duo.


B

Passwords - KeePassXC

Title	Username	URL	Notes
accounts.google.com	nated3546@gmail.com	https://accounts.google.com/v3/...	
Bitcoin Wallet Seed			how now brown cow
en.wikipedia.org	nated35467	https://en.wikipedia.org/w/index...	
Mastercard			MasterCard

Root / KeePassXC-Browser Passwords / Personal / accounts.google.com

Username nated3546@gmail.com
URL https://accounts.google.com/v3/signin/challenge/pwd
Password ••••••
Expiration Never
Tags gmail
Notes

» Premium users also benefit from a built-in TOP generator for stored accounts, as well as regular password hygiene and vault reports to make sure that none of your credentials have been compromised.

» Bitwarden's password database has never been breached by hackers, but in early 2023, a vulnerability was discovered in the 'autofill' feature of the web extension, which could lead to the password being entered into an untrusted domain like a phishing website. The software has since been updated to warn users if they're entering login details into a form other than the one for the page they're visiting.

2

KEEPASSXC

First release: 2012
Supported OS: Linux, macOS, Windows
Browser extension: Chrome, Firefox, Edge, Vivaldi, Tor
Mobile version: No (Compatible mobile apps available)
Available in Microsoft Store: Yes

KeePassXC is an open-source fork of the now defunct KeePassX, which itself is derived from the original KeePass. We've selected this one over the original, as it's cross-platform, plus setup is slightly easier [Image B].

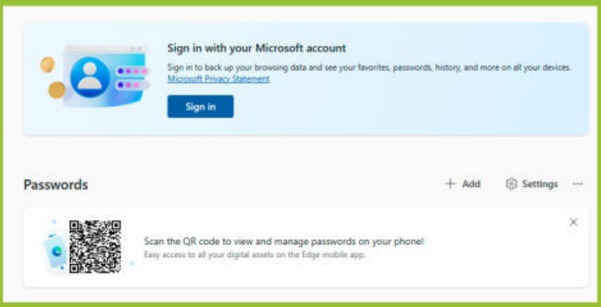
» This password manager is extremely lightweight, as it's written in C++ using the Qt framework. However, this means that in order to use KeePassXC, you first need to install the Microsoft visual C++ Library, available via: https://aka.ms/vs/16/release/vc_redist.x64.exe

» Unlike other popular password managers KeePassXC isn't cloud-based. Instead, during setup, you create a dedicated database file (.kdbx) to be stored on your device. Naturally, you can save the file to a cloud folder like Dropbox if you prefer. For best compatibility, KeePassXC recommends choosing the most recent KDBX4 format for your password database.

» Security consultant Zaur Molotnikov did an in-depth review of KeePassXC's core functions in 2022, and came away impressed (read it at https://molotnikov.de/docs/KeePassXC-Review-V1-Molotnikov.pdf).

» This may partly be due to the fact that during database creation, users are asked to specify a database decryption time. By default, .kdbx files are encrypted with 256-Bit AES, though you can choose Twofish or ChaCha20 if you prefer. Like Bitwarden, KeePassXC also uses the Argon2d KDF.

BROWSER PASSWORD MANAGERS


Sign in with your Microsoft account

Sign in to back up your browsing data and see your favorites, passwords, history, and more on all your devices.
Microsoft Privacy Statement

Passwords

Scan the QR code to view and manage passwords on your phone!
Easy access to all your digital assets on the Edge mobile app.

Standalone password managers would seem to be a moot point when every modern browser can save your credentials for you. Why, then, would you want to install a separate product? The answer here lies in the question: browsers are not specifically designed as password managers, so operate in a different way.

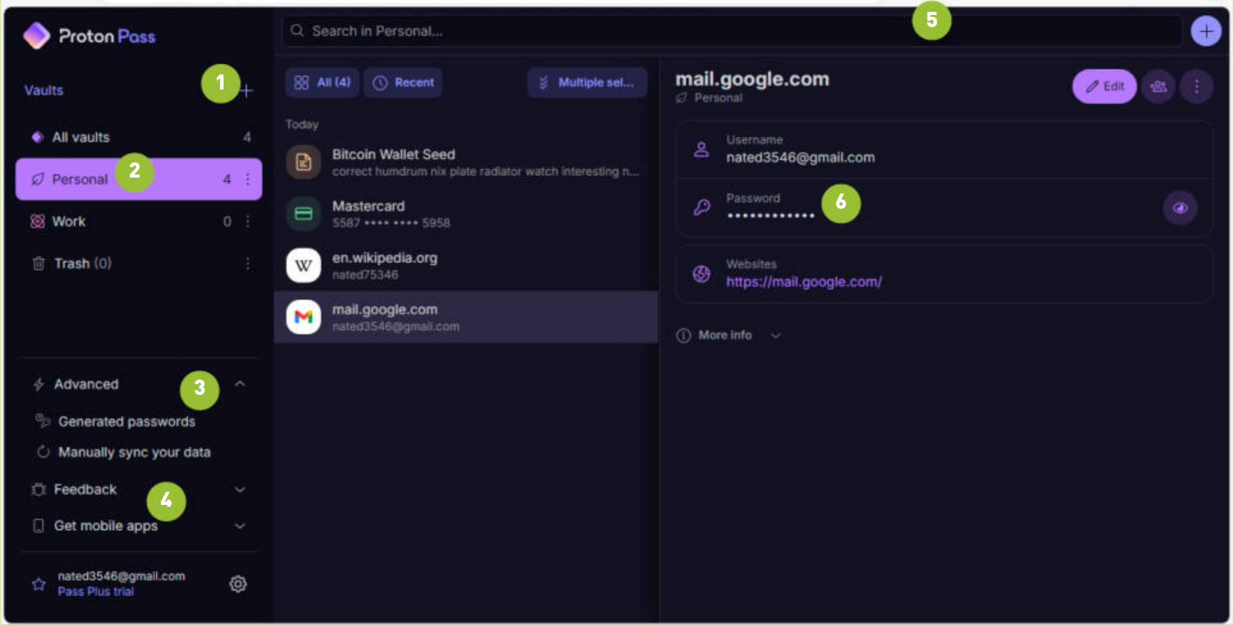
Some users of Chromium-based browsers like Chrome and Edge have discovered this the hard way after their devices were infected by Redline Stealer. This malware targets the 'Login Data' file, an SQLite database created by browsers to store login credentials. If it runs on the same user account, Redline can decrypt 'Login Data' and access your passwords.

Admittedly, in a scenario where your device is infected with malware, there's always a chance that your credentials will be harvested. Still, dedicated password managers like KeePassXC allow you to choose where to store the password database. Most password managers also allow you to lock or sign out of the database, which is protected by a master key—not just your login password.

Most importantly, the best open-source password managers like Bitwarden protect all your credentials using end-to-end encryption, meaning that even if the cloud server was hacked or seized, the data would be useless without the correct master key.

©KEEPASSXC

THE IDEAL PASSWORD MANAGER


https://pass.proton.me/u/1/share/fxtSqGvQfks7AUUsBvDA2_bEtAPYrw4VtGCLOD3tEmpwJRKyV...
Proton Pass
Search in Personal...
Vaults
All vaults 4
Personal 4
Work 0
Trash (0)
Advanced
Generated passwords
Manually sync your data
Feedback
Get mobile apps
nated3546@gmail.com
Pass Plus trial
All (4)
Recent
Multiple sel...
Today
Bitcoin Wallet Seed
correct humdrum nix plate radiator watch interesting n...
Mastercard
5587 •••• •••• 5958
en.wikipedia.org
nated75346
mail.google.com
nated3546@gmail.com
Edit
More info
1
2
3
4
5
6

mail.google.com
Personal
Username nated3546@gmail.com
Password ••••••••••••
Websites https://mail.google.com/

1. MULTIPLE VAULTS
Your password manager should allow you to create multiple independent databases, each secured with their own master key. For instance, you can have one for your web logins and another for sensitive financial information.

2. CREDENTIAL CATEGORIES
If you have a lot of credentials, make sure your password manager supports grouping into specific categories. Bonus points if you can also add a colorful icon to help distinguish between them.

3. PASSWORD GENERATOR
The ideal password generator suggests unique, strong passphrases each time you create a new account. It should also alert you if any existing passwords have been exposed in a data breach.

4. MOBILE VERSION
Juggling two password managers is bad for your self-organization and a nightmare for security. Make sure your password manager offers compatible mobile apps to sync your passwords across all devices.

5. BROWSER EXTENSION
Check that your chosen password manager offers a compatible browser extension. This should be available via the official add-ons page. You may need to enable it from within the manager settings.

6. ZERO KNOWLEDGE
All credentials should be encrypted using end-to-end encryption via the master key. Bonus points if the password manager has integrated support for storing and generating TOTP (two-factor authentication codes).

» The final stage of setup involves setting a master password, for which you can use KeePassXC's own password generator. This can produce both passwords (by default 17 random characters) or passphrases (default 7 random dictionary words). Both options offer around 100 bits of entropy.

» Users can also specify a 'keyfile' to open the database. KeePassXC can generate a (.keyx) file with random bytes, or you can use an arbitrary file such as one JPG in a collection of family photos. Database login via hardware tokens like Yubikey or Onlykey is also supported.

» Once a database is created, users can edit keyfiles and any other database settings from the main menu. There are no limit to the number of databases that KeePassXC can manage, so you can have a dedicated one to store banking information, for instance.

» Browser extensions are available, but first integration must be enabled in the software's settings. KeePassXC offers granular control of this feature, allowing you to enable integration for some browsers, but not others. When you add passwords and other sensitive information, you can also choose to block the browser extension from accessing it. KeePassXC can also store and generate TOTP credentials.

» During our first test, we signed into a Gmail account and noticed that KeePassXC stored the password, but not the username. After entering this manually, we then created a Wikipedia account. Right-clicking on the password field displays KeePassXC's options, including suggesting a secure password. A pop-up then appeared, allowing us to store the credentials.

» The password manager allows creation of groups for particular credentials, eg. 'Work' & 'Personal'. When adding online accounts, we also noted that KeePassXC adds an appropriate 'FavIcon' for each entry, making it easy to distinguish. This feature requires network access, so you may prefer to simply use KeePassXC offline and use the default favicons.

» KeePassXC seems to lack any simple automatic way to add other types of sensitive data, like credit card information or Bitcoin wallet seeds. True, each entry has a 'Notes' feature where you can store arbitrary

© PROTONPASS

information. You can also modify entry attributes and create custom fields, but we feel that something as basic as credit card numbers should be offered, especially given most browser-integrated password managers can use autofill to add payment information these days.

» The developers also admit that an Android or iOS version of KeePassXC would require an extensive code rewrite, so doesn't seem very likely. However, the KDBX database format is supported by a number of mobile apps, such as KeePass2 (Android) and Strongbox (iOS).

» You can also use the 'KeeShare' feature to specify credentials to share with others, provided they have compatible software.

3 PROTON PASS

First release: 2023
Supported OS: Linux, macOS, Windows
Browser extension: Chrome, Edge, Firefox, Brave
Mobile version: Yes (Android & iOS)
Available in Microsoft Store: No

Proton Pass is the newest password manager on the block, with its first stable release in April 2023. Still, its bona fides are assured by main developer Proton, who since 2014 has released a number of privacy-friendly products, including Proton Mail.

» The free version of Proton's open password manager allows you to store an unlimited number of passwords and sync them across virtually all devices. It supports every major OS and mobile platform.

» All login credentials are secured using end-to-end encryption and synced to Proton's servers, which are based in Switzerland, a country known for its strong privacy laws.

» You don't need a Protonmail address to use Proton Pass, but you will need to provide a verified email and password to sign up. Upon registration, Proton also provides a 'recovery kit' PDF, which allows users to recover their account if the master password is lost.

» You are then prompted to install Proton Pass as an extension in your browser of choice. The setup screens also display a helpful introductory video on how to use the platform and prompt you to install the mobile versions of the app.

» Proton currently offers a seven-day trial of 'Pass Plus' features, where for just under $3 per month, you can benefit from an integrated 2FA authenticator and access to Proton's 'Sentinel' platform.

» Still, the free version should be sufficient for most users, given that it not only supports storage of any number of passwords, but also card details and encrypted 'notes' for other types of information, like cryptocurrency wallet seed phrases.

» The extension allows users of the free tier to launch the web app, which allows easy creation of up to 10 email aliases, as well as more advanced features like auto-locking the database.

» In November 2023, a security flaw was discovered with this feature in that the lock didn't automatically clear unencrypted credentials that Proton Pass was storing in the device memory. Proton has since released a fix for this.

» Both the web extension and web app contain a password generator, which by default creates a passphrase of four dictionary words separated by random numbers and hyphens (around 243 bits of entropy).

» According to the developer blog, instead of relying on a standard key derivation algorithm, the software uses Proton's own implementation of bcrypt to hash passwords, which they claim is more secure than PBKDF2.

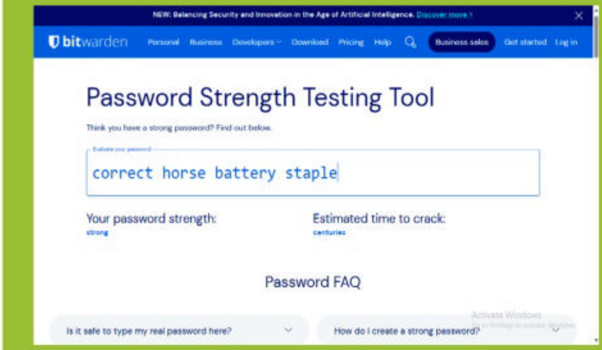
» They go on to explain that when users create a vault, Proton Pass generates a 32-byte random vault key. This is itself encrypted and signed with the user key, ensuring that only that user can decrypt their own vault. All items in Proton Pass are encrypted using 256-bit AES-GCM.

» Vault administrators can share their vault key with others. If they do so, Proton Pass encrypts it with the recipient's address key, ensuring only they can access it.

» Another impressive Proton Pass feature is how it manages importing databases from other password managers. This can be accessed via 'Settings', and most major platforms are supported provided the data to be imported is in CSV, JSON or XML format.

» During our tests, Proton Pass initially failed to store the credentials for the Gmail account, possibly because it was already signed in. However, when we added the login details manually and restarted the browser, the web extension sprung to life and filled in the login credentials. When we tried to create a Wikipedia account, Proton Pass also immediately suggested a strong, unique password, and stored the login information.

MASTERING YOUR PASSPHRASE



Password Strength Testing Tool

Think you have a strong password? Find out below.

Evaluate your password: correct horse battery staple

Your password strength: strong

Estimated time to crack: centuries

Password FAQ

Is it safe to type my real password here?

How do I create a strong password?

Using a reliable password manager means you're protecting all your credentials using 'zero knowledge' via your master passphrase.

Our first advice is to make sure this isn't the only way you secure your password database—all the software in this guide supports login via 2FA, and in most cases you can use hardware keys like YubiKey or 'keyfiles' to add a further layer of protection.

Beyond this, it stands to reason that your master password should have sufficient entropy. In other words, it shouldn't be easily guessable or able to be cracked using 'brute force' techniques. You also need to be sure that you can recall the password easily.

The best method to create secure passwords you can remember is to use Diceware (https://diceware.dmuth.org). This involves using dice (or an RNG) to select dictionary words at random from a list. The site itself can generate passwords for you, but the ultra-paranoid can actually download a word list and break out physical dice.

The default list is perfectly secure, but British/Canadian users can also make use of the Beale list (www.diceware.net/?dicelist=beale), which contains UK spelling and fewer Americanisms.

If you're unsure whether your master password is strong enough, Bitwarden offers a free strength meter: https://bitwarden.com/password-strength.

© XKCD, AMD

Control your settings with the Nvidia app

YOU'LL NEED THIS

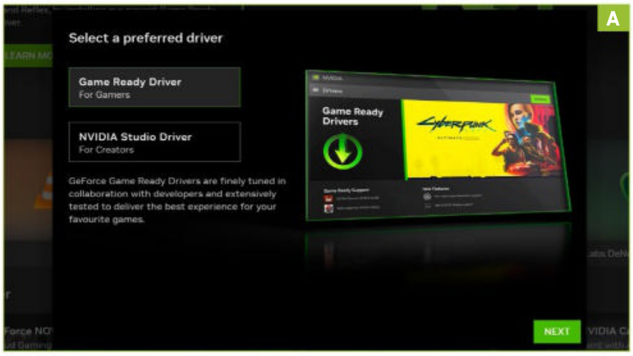
NVIDIA GRAPHICS CARD

Some games

ACOLYTES OF TEAM GREEN have had an array of GPU-focused software to contend with since GeForce Experience arrived in 2013. It's the app you'd open to update drivers or optimize the graphics settings of a particular game, but if you wanted to set up G-sync, change digital audio settings, or view the HDCP status of your display, you'd need to open the Nvidia Control Panel.

You'd also need to log in with an Nvidia account just to update your drivers, something that added an extra level of aggravation nobody wanted. Thanks to the new Nvidia app that's now gone, though there's now a rewards scheme that requires a login (this can be skipped).

The Nvidia app is more than a reskin of GeForce Experience, though the really granular settings are still hived off in the Control Panel. You get a redesigned interface that offers per-game and global settings for things like VSync and shader cache sizes, as well as driver updates and the ability to switch between Game Ready and Studio drivers. **–IAN EVENDEN**



Select a preferred driver

Game Ready Driver
For Gamers

NVIDIA Studio Driver
For Creators

GeForce Game Ready Drivers are finely tuned in collaboration with developers and extensively tested to deliver the best experience for your favourite games.

1 INSTALLATION

Installing the Nvidia App beta is fairly straightforward. Head to https://www.nvidia.com/en-us/software/nvidia-app and click the big green Download Beta button. It's worth pointing out that, as the site makes clear, this is beta software, and therefore might be prone to the little niggles that often accompany an app that needs more time in the oven—things like instantly crashing when you open it. If your PC is a crucial part of your workflow, then don't install this software until the first stable release.

» The installer can take a bit of time to do its thing, and when we thought it had crashed and tried to close it, it provided one of the best error messages we've ever seen. It's rather threatening, with a hint of Terminator about it, and will probably be rewritten by the time the final version of the app becomes available.

2 MEET THE APP

The first thing you'll see when you open the Nvidia app for the first time is a box asking you to choose between the Game Ready or Studio drivers [**Image A**]. They both do the same thing—allow the operating system and apps on your PC to make use of the GPU's processing capabilities—but the Game Ready driver is the bleeding-edge edition that's updated most frequently and with specific games in mind. The Studio drivers don't have this focus on game optimization, but are designed for creative apps, such as 3D rendering or video editing that require stability. It's possible to run creative apps with Game Ready drivers, as is to run games with Studio drivers. However, in the latter case you'll be losing out on performance, and in the former you'll be risking a crash that could cost you time and money.

3 HOME PAGE

With that out of the way, you'll be on the home page of the app. Unlike the GeForce Experience, the Nvidia app is divided into tabs, which can be switched between on the left-hand side of the interface. It's a little bit like the Steam app in that it offers 'shelves' of content, with rotating news and announcements at the top, some of your commonly played games under that, and links to further Nvidia services below.

» If you've upgraded from GeForce Experience, the app retains the scanning locations you set, so should pick up all your installed games. Clicking on a game allows you to either launch it or access its settings, but as before, the game needs to be compatible, and you need to have launched it once to be able to adjust its graphics settings in this way.

4 GAME LOCATIONS

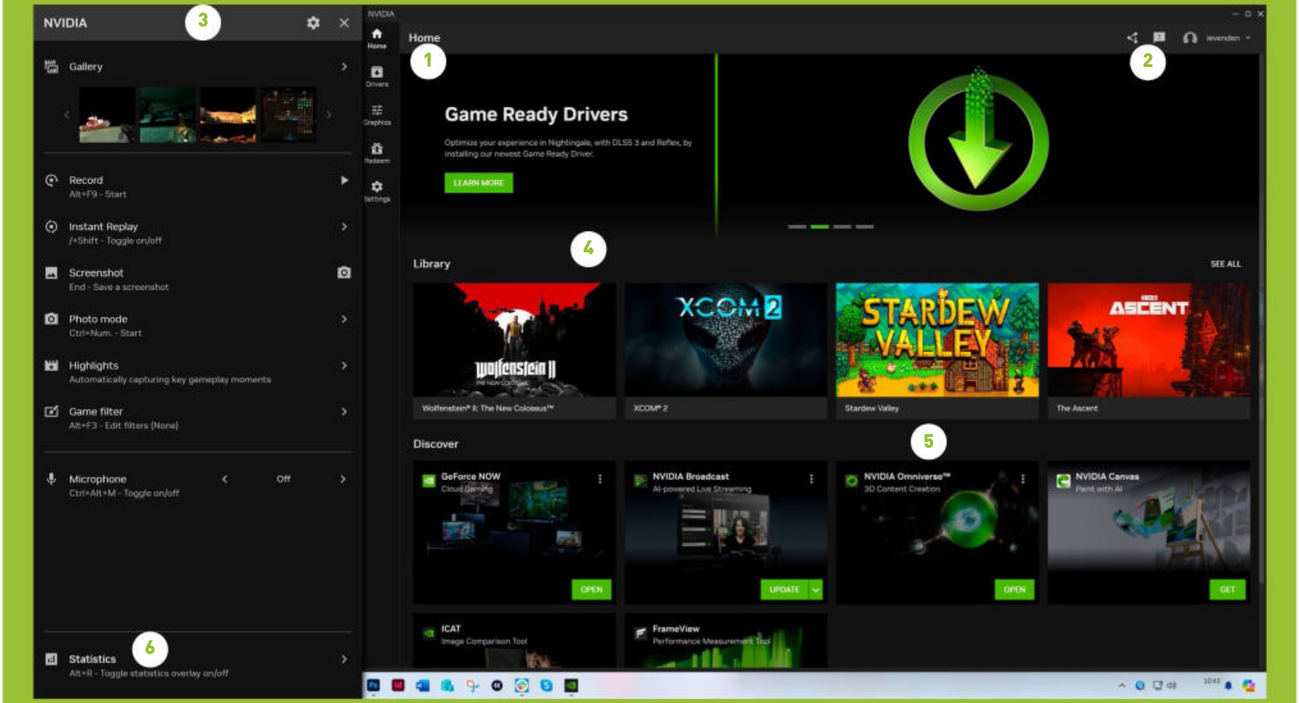
If you're new to the app, you'll need to tell it where your games are so it can detect them. Open the Settings tab, and scroll down to Games and Apps. Click View and Modify, and tell the app where your installation folders are for Steam, Uplay, Epic, and all the digital marketplaces you're signed up for. If you're only running with one SSD in your rig then this will be a simple process, but if you have a tower with multiple drives then it might take a while to locate them all. The Nvidia app can automatically optimize newly installed games' settings for your GPU, and you can activate this by sliding the switch next to 'Automatically optimize newly added games and applications'. This can save time in the game's settings when you just want to play, but won't squeeze every last frame of performance from it.

5 OPTIMIZE GAMES

Click 'See All' next to the Library shelf on the home page, or on the Graphics tab, and you'll be taken to a list of all the games the app has found on your PC. From here, you're able to tweak settings individually, from detail levels and DLSS to VSync and more. Games that are optimized for your rig have a green tick by them, and you're able to use a slider to choose a happy medium between quality and performance. Perhaps

© NVIDIA

APP LAYOUT


NVIDIA
3
Gallery
Home
Drivers
Graphics
Redeem
Settings
1
2
Game Ready Drivers
Optimize your experience in Nightingale, with DLSS 3 and Reflex, by installing our newest Game Ready Driver.
LEARN MORE
4
Library
SEE ALL
Wolfenstein® II: The New Colossus™
XCOM 2
Stardew Valley
The Ascent
Discover
5
GeForce NOW
Cloud Gaming
OPEN
NVIDIA Broadcast
AI-powered Live Streaming
UPDATE
NVIDIA Omniverse™
3D Content Creation
OPEN
NVIDIA Canvas
Paint with AI
GET
ICAT
Image Comparison Tool
FrameView
Performance Measurement Tool
6

Record
Alt+F9 - Start

Instant Replay
/+Shift - Toggle on/off

Screenshot
End - Save a screenshot

Photo mode
Ctrl+Num. - Start

Highlights
Automatically capturing key gameplay moments

Game filter
Alt+F3 - Edit filters (None)

Microphone Off
Ctrl+Alt+M - Toggle on/off

Statistics
Alt+R - Toggle statistics overlay on/off

1. TABS Switch between the Home, Drivers, Graphics, and Redeem tabs here, plus Settings.

2. OVERLAY BUTTON Press this, or use Alt + Z, to open the Nvidia overlay, which now appears as a sidebar.

3. THE OVERLAY Options for screen recording, screenshots, highlights reels, and filters.

4. LIBRARY This shelf on the Home tab gives access to games' settings.

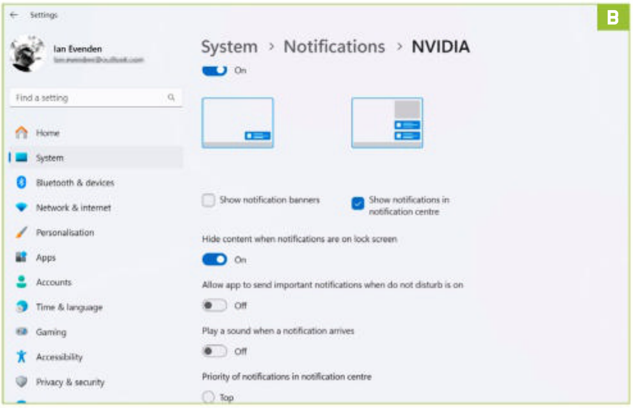
5. DISCOVER Nvidia does more than just make graphics cards. Who knew?

6. STATISTICS Open the frame rate counter, view latency, and other useful stuff.

more interesting is the Global Settings tab, which allows you to set maximum frame rates, shader cache sizes (which can speed up game loading at the expense of SSD space by saving shaders once a game has compiled them), and set whether or not your monitor is G-Sync compatible.

6 THINGS THAT AREN'T GAMES

The Nvidia app will also pick up apps on your PC that aren't games, but use the GPU. On our test PC, it offered options for OBS Studio, such as the video encoding methods used, and driver settings that were largely covered by the Global Settings above. It also offered to optimize Adobe Lightroom (whether or not to use the GPU for image processing) and the Topaz AI suite of image processing suites, which make heavy use of the GPU.


B
Settings
Ian Evenden
Find a setting
Home
System
Bluetooth & devices
Network & internet
Personalisation
Apps
Accounts
Time & language
Gaming
Accessibility
Privacy & security

System › Notifications › NVIDIA

On

☐ Show notification banners

☑ Show notifications in notification centre

Hide content when notifications are on lock screen
On

Allow app to send important notifications when do not disturb is on
Off

Play a sound when a notification arrives
Off

Priority of notifications in notification centre
○ Top

7 REWARDS

Nvidia still wants you to have an account, even though it has now decoupled driver updates from it, and the Redeem tab is where you'll find the 'rewards' for this. Oddly, we saw a Call of Duty XP boost reward was active when not logged in, which disappeared when we logged into the app, leaving no rewards at all. This is beta software, however, so perhaps this will be fixed by the time the first stable version is released.

8 NOTIFICATIONS

Open up the Settings tab, and you can set whether or not the app pops up a notification in Windows when there's a driver update available (very useful) or when there's a new reward out for you (potentially less useful). It also contains a handy link to Windows' own notification settings pane [**Image B**], from where you can set whether the notifications become part of the general Notification Center, or have their own, more intrusive style like GeForce Experience did, and also set the priority of these messages in the Notification Center stack. ⏻

Make Shortwave your AI Assistant

YOU'LL NEED THIS

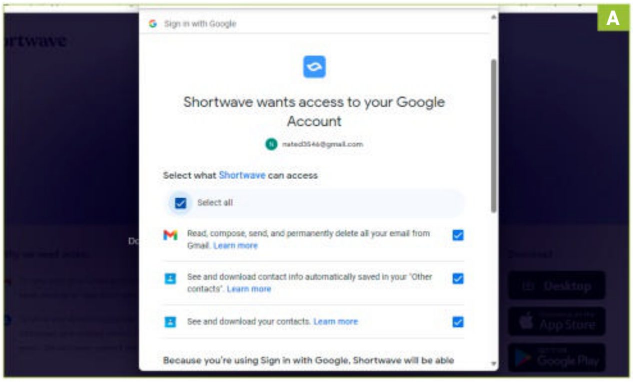
SHORTWAVE
A Google/Google Workspace account

SHORTWAVE IS THE CREATION of a number of ex-Google developers, who seem to be reaching for the holy grail of helping users organize their email inbox once and for all. The good news is that if you're on PC, there's no downloadable client to install; you only need to sign in via your Google account.

Shortwave makes use of 'bundles' and 'labels' to categorize messages into rows. You can also schedule delivery of messages so that your device isn't pinging every few seconds.

The recent inclusion of an AI assistant allows for quick summaries of message lists, scheduling reminders and even drafting suitable replies, automating the headache of navigating through dozens of messages at a time.

In this guide, you'll discover how to get started with Shortwave, group your messages neatly into categories, and even let AI do the hard work of scheduling appointments and drafting messages for you. **–NATHAN JORDAN**



Shortwave wants access to your Google Account

Select what Shortwave can access

☑ Select all

Read, compose, send, and permanently delete all your email from Gmail. Learn more ☑

See and download contact info automatically saved in your 'Other contacts'. Learn more ☑

See and download your contacts. Learn more ☑

Because you're using Sign in with Google, Shortwave will be able

1 SET UP SHORTWAVE

To use Shortwave, you need to have a Google/Google Workspace account, though the developers hope to support more providers in future.

» Although mobile versions are available, to get started on your PC simply head to https://shortwave.com and click 'Sign in with Gmail' > 'Sign in with Google' to begin. As you do so, make sure you pay close attention to the permissions required by Shortwave, as naturally it needs to be able to view, edit, and send emails. [**Image A**]

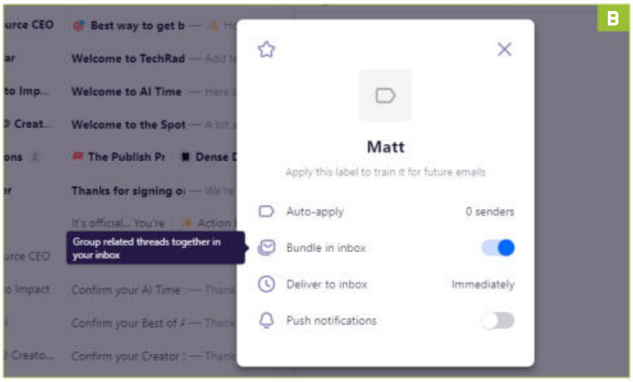
» Upon first logging in, you'll notice a new email entitled 'Welcome to Shortwave'. Get started by clicking into this. Here, you'll see the developers' bold claim that you can hit 'Inbox zero' by marking certain items as 'Done'. Once you've read through this, click the checkbox in the top-right corner to mark this email as actioned. There's also a corresponding button in the top right of the main inbox to mark emails as 'All Done'.

» If you do return to the main inbox, you'll notice that certain emails have been grouped together in horizontal rows that Shortwave calls 'Bundles'. These offer a quick and easy way to view emails in a similar category. Bundles are automatically determined by Shortwave, but you can add and configure them further.

» Take a moment to click into one of these, eg. 'Newsletters', to view listed messages. Click the settings icon next to the bundle name. From here, you can choose to disable bundling messages like these. [**Image B**]

» Another great aspect of Shortwave is the ability to configure how and when certain messages are delivered. Click 'Immediately' in the Settings menu to manage the delivery schedule to your inbox, eg. daily at 8am. You can also enable or disable push notifications from here.

» You can add an email to an existing bundle by opening it, then clicking options (...) > Label. Scroll down and check your chosen bundle, eg. 'Newsletters', as well as 'Apply Changes to Future Messages'. [**Image C**]



Matt

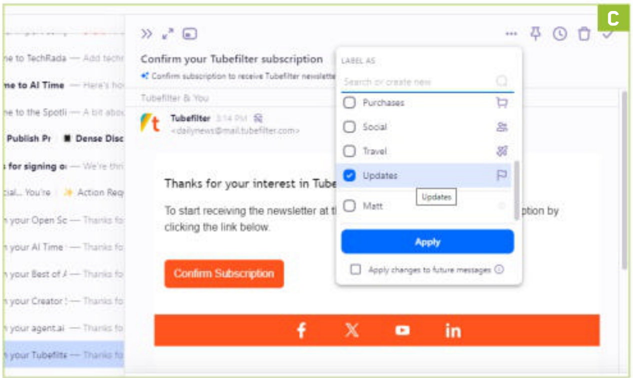
Apply this label to train it for future emails

Auto-apply: 0 senders

Bundle in inbox: on

Deliver to inbox: Immediately

Push notifications: off



Confirm your Tubefilter subscription

Tubefilter <dailynews@mail.tubefilter.com>

Thanks for your interest in Tube

LABEL AS

☐ Purchases

☐ Social

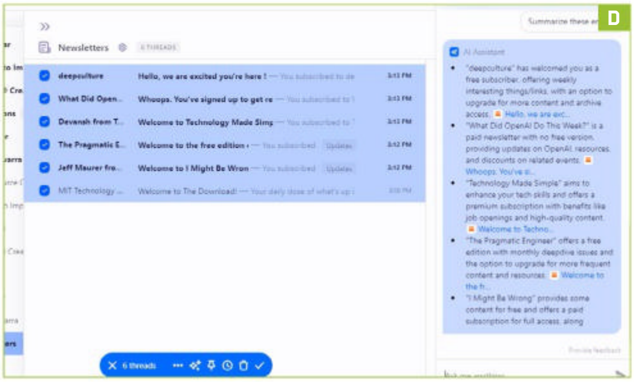
☐ Travel

☑ Updates

☐ Matt

☐ Apply changes to future messages

© SHORTWAVE.COM



Newsletters

deepculture — Hello, we are excited you're here !

What Did Open… — Whoops. You've signed up to get re

Devansh from T… — Welcome to Technology Made Simp

The Pragmatic E… — Welcome to the free edition

Jeff Maurer fro… — Welcome to I Might Be Wron

MIT Technology… — Welcome to The Download!

AI Assistant

- "deepculture" has welcomed you as a free subscriber, offering weekly interesting things/links, with an option to upgrade for more content and archive access. Hello, we are exc...
- "What Did OpenAI Do This Week?" is a paid newsletter with no free version, providing updates on OpenAI resources and discounts on related events. Whoops. You've si...
- "Technology Made Simple" aims to enhance your tech skills and offers a premium subscription with benefits like job openings and high-quality content. Welcome to Techno...
- "The Pragmatic Engineer" offers a free edition with monthly deepdive issues and the option to upgrade for more frequent content and resources. Welcome to the fr...
- "I Might Be Wrong" provides some content for free and offers a paid subscription for full access, along

2

DO MORE WITH BUNDLES

Shortwave not only groups emails together for you via email; it can also provide you with a summary of all messages via the AI assistant.

» To see this in action, open any Bundle once again, and hit the button marked 'Summarize this Bundle' in the top right. This will open the AI assistant. [**Image D**]

» Once you've read through the summaries, use Ctrl + J to close the assistant (you can also summon it in the same way).

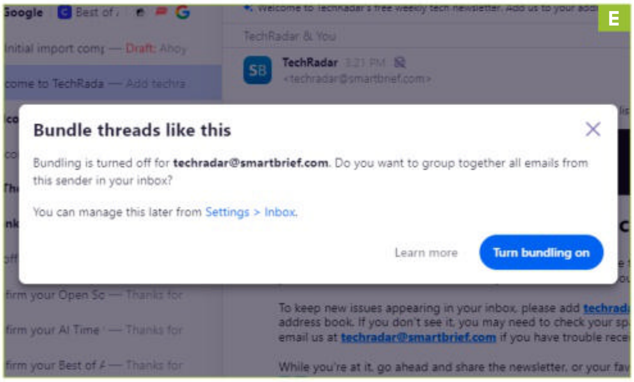
» Currently, the AI can't actually create bundles or labels for you, but you can easily do so yourself—eg. for messages from the same sender, simply by opening an email then options (...) > 'Bundle Threads like this'.

» Shortwave will display a notification saying that this feature is currently disabled. Click 'Turn bundling on' to continue. You can also create a dedicated label for your bundle by opening it, choosing more options (...) > Label > then typing the new name. Choose 'Bundle in Inbox' in the configuration screen to display the newly named bundle. [**Image E**]

» You can also use shortcuts to access common bundles. Simply hit '+' in the left-hand pane. In the search field, enter 'label:<yourlabelname>' e.g. 'label:newsletters'. Next, hit return. The shortcut will now appear in the left-hand pane. Select it to list only emails in that bundle. [**Image F**]

» In order to fine-tune your inbox even further, click the Settings option in the bottom left corner of the screen. First, select 'Turn On' under 'Enable Notifications' to enable push notifications. Next, select 'Inbox Settings' to access your label and contact rules.

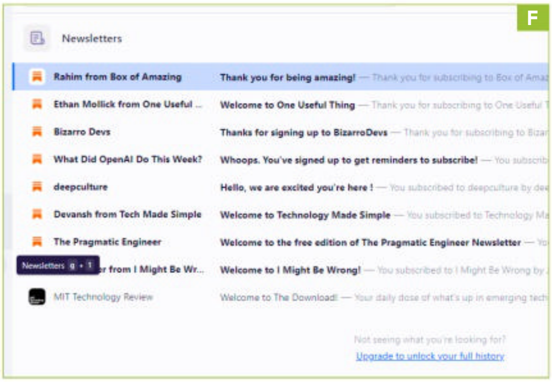
» This essentially is a quick and easy way to manage how and when emails from various contacts and/or bundles are delivered to your inbox. Click 'Immediately' under 'Deliver to Inbox' on each of these to amend the delivery schedule. Note that you can choose 'Never' so that certain types of email don't automatically appear in your inbox.



Bundle threads like this

Bundling is turned off for techradar@smartbrief.com. Do you want to group together all emails from this sender in your inbox?

You can manage this later from Settings > Inbox.



Newsletters

Rahim from Box of Amazing — Thank you for being amazing! — Thank you for subscribing to Box of Amaz

Ethan Mollick from One Useful ... — Welcome to One Useful Thing — Thank you for subscribing to One Useful T

Bizarro Devs — Thanks for signing up to BizarroDevs — Thank you for subscribing to Bizar

What Did OpenAI Do This Week? — Whoops. You've signed up to get reminders to subscribe! — You subscrib

deepculture — Hello, we are excited you're here ! — You subscribed to deepculture by dee

Devansh from Tech Made Simple — Welcome to Technology Made Simple — You subscribed to Technology Ma

The Pragmatic Engineer — Welcome to the free edition of The Pragmatic Engineer Newsletter — Yo

r from I Might Be Wr... — Welcome to I Might Be Wrong! — You subscribed to I Might Be Wrong by

MIT Technology Review — Welcome to The Download! — Your daily dose of what's up in emerging tech

Not seeing what you're looking for?

Upgrade to unlock your full history

3

ARMING UP WITH AI

Shortly after signing up for Shortwave, you'll have received an email from the developers inviting you to upgrade. This provides a good opportunity to learn how the AI assistant can schedule reminders. Simply open the email, then invoke the Assistant with Ctrl+J. Give it a simple prompt, such as: 'Please set a reminder for me in 30 days to upgrade Shortwave if it's working for me.'

» The AI Assistant will explain that it needs access to your Google Calendar. Click 'Grant Google Calendar Permissions' to sign in via your account.

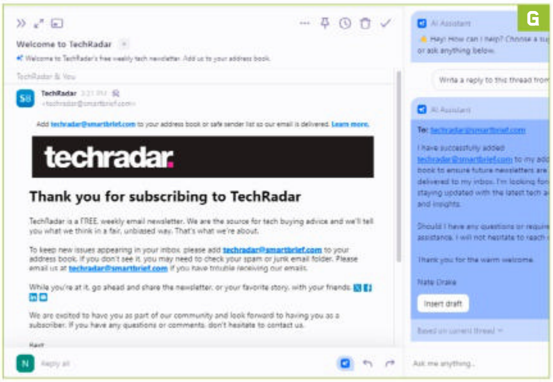
» Next, enter your request to the AI assistant to set the reminder once more. This will appear in the chat pane. Click 'Create Event' to confirm.

» The AI assistant really comes into its own when helping you reply to emails. To get started, open a message, and hit Ctrl + J. If you're happy with a bland, GPT- like response, you can just enter the command: 'Write a Reply to this thread from scratch.' [**Image G**]. Paid subscribers can train the assistant to their writing style and provide prompts about responses, like starting an email with 'Hey'.

» You can also have the assistant provide a more tailored response, eg. 'Please write a reply thanking them for importing the emails. Tell them I plan to evaluate Shortwave for a month before I begin training for my mission to Mars.'

» If you're unhappy with the response, you can provide prompts, such as 'Make shorter' or 'Make Less Formal'. The free version of the assistant supports a range of writing styles, even 'Pirate English'.

» Once you're happy with the text, click 'Insert Draft'. Although the text is inserted into the email, you have to click 'Send' yourself or 'Schedule Send' to send later.



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TechRadar

Add techradar@smartbrief.com to your address book or safe sender list so our email is delivered. Learn more.

techradar

Thank you for subscribing to TechRadar

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While you're at it, go ahead and share the newsletter, or your favorite story, with your friends.

We are excited to have you as part of our community and look forward to having you as a subscriber. If you have any questions or comments, don't hesitate to contact us.

AI Assistant

Hey! How can I help? Choose a su or ask anything below.

Write a reply to this thread from

AI Assistant

To: techradar@smartbrief.com

I have successfully added techradar@smartbrief.com to my add book to ensure future newsletters are delivered to my inbox. I'm looking fo staying updated with the latest tech a and insights.

Should I have any questions or require assistance, I will not hesitate to reach

Thank you for the warm welcome.

Nate Drake

Turn on hidden Windows tools

YOU'LL NEED THIS

VIVETOOL AND WINDOWS 10 OR 11
github.com/PeterStrick/ViVeTool-GUI

WINDOWS IS BEING CONSTANTLY DEVELOPED, and Microsoft makes new beta features available on a rolling basis. However, many are available only to Windows Insiders signed up to preview versions. The good news is that you can often enable these features yourself. One of the easiest ways to do this is with ViVeTool.

Here, we'll show you how to download pre-release versions of Windows and use ViVeTool to enable features. Before starting, make a backup of your system. The features that ViVeTool can activate are experimental, so proceed with caution. –NIK RAWLINSON

1 SIGN UP FOR WINDOWS INSIDER

First, you need to turn on optional diagnostic data in Windows. Press Windows key+I to open Settings, then in Windows 10, click Privacy (or 'Privacy & security' in Windows 11), followed by 'Diagnostics & feedback'. Now, make sure the slider in the 'Send optional diagnostic data' section is on [**Image A**] . Once that's done, click Windows Update on the left, followed by Windows Insider Programme in the main part of the window. Next, click the blue 'Get started' button, followed by 'Link an account'. Select your Microsoft account in the box that appears, then click Continue, and choose which 'channel' you want to sign up to.

» There are four to choose from, ranging from the Canary Channel (an 'unstable' release for 'highly technical users') to the Release Preview (which is the closest version to what will be officially released). Microsoft recommends the Beta edition [**Image B**], which is one stage before the Release Preview, and more stable than the Canary Channel. Click the channel you're comfortable working with, then click Continue.

» Now, confirm that you agree with the terms and privacy notice, then restart your computer. When it's up and running again, return to the Windows Update section of the Settings tool, and check for updates. This time, it should find an Insider Preview build of Windows. Download all the updates that it offers.

2 DOWNLOAD VIVETOOL

First, head to tinyurl.com/4ef49skb. This is ViVeTool's page on GitHub, which is a Microsoft-owned service that developers use to manage and share code. ViVeTool is on an update cycle, which means that there are several versions available to be downloaded at any time. Download the latest version, though it might be best to avoid any builds labeled 'Emergency'.

» Download your chosen build by clicking the arrow to the left of the Assets header, followed by 'ViVeTool.GUI.Setup.exe' [**Image C**]. Once the program has downloaded, launch it. Windows will check that you really want to run the file. Let it do so, then follow the instructions to install ViVeTool.

3 SELECT YOUR VERSION OF WINDOWS

Not every disabled feature appears in every version of Windows. This is why you have to tell ViVeTools what version of Windows you're using. Open Windows Settings again, then click System in the sidebar. Now, scroll down to the bottom of the main panel, and click 'About'. Carry on scrolling to the 'Windows specifications' section, then note the number listed beside 'OS build'.

» Now, return to ViVeTool, click the drop-down menu in the top left corner, then look for and select your build number [**Image D**]. If you can't find the specific build, look for the closest number below it—this will be the next earliest release of Windows. Be aware, though, that this might bring up features that aren't available in your version of Windows.

4 CHOOSE A FEATURE TO TURN ON

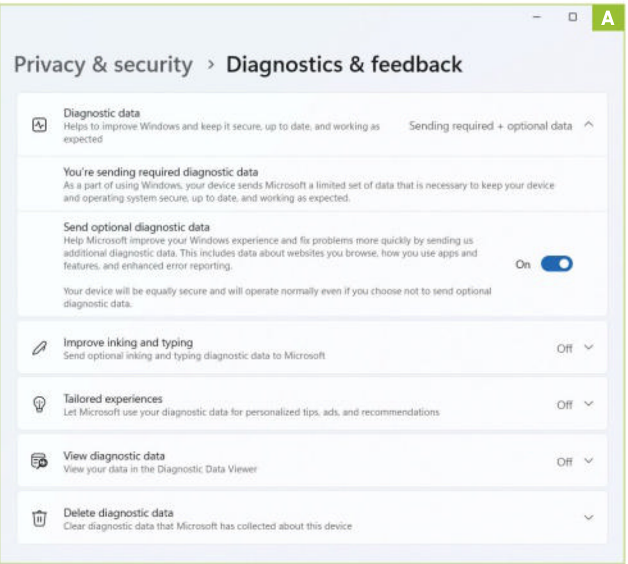
Having selected a Windows build, ViVeTool assembles a list of features that it contains. As you'll see if you expand the sections, each feature has both a name and a Feature ID number, the latter typically comprising seven or eight digits.

» These Feature IDs are important, as they identify what task they perform. It's not always easy to find which IDs you might want to change, as several IDs can be tied to a single feature. The best strategy is to first search for a specific feature that you know your version of Windows contains, but isn't activated, or to search more generally for a part of Windows that you'd like to improve. In our example, we searched for tabs [**Image E**] .

» If you know what a feature does, and want to turn it on, select it by clicking so that it's highlighted in blue. Next, click Perform Action at the top, and click the Activate Feature option. You'll see a green message confirming that it has been successfully enabled. If it doesn't work, or you don't like it, click Deactivate Feature.

» The other way to find features is to search for Feature IDs. These won't mean anything to you unless you do a bit of research. You could search for them online, but that could generate lots of irrelevant results. It's better to visit a forum offering advice. For example, the Microsoft Community site (which is not affiliated with Microsoft) has posted a selection of IDs at tinyurl.com/mrwuf9xx [**Image F**].

» Some features require you to activate two or more IDs. One good example is getting instant search results in File Explorer as you type, for which you need to activate both 39281392 and 38665217. To search by ID number in ViveTool, just type in the box in the top left. As you type, it will try to predict which feature you're looking for and highlight it. You can turn it on by clicking the 'Perform Action' button. Then, close ViVeTool, and restart your computer for the changes to take effect.


A

Privacy & security › Diagnostics & feedback

Diagnostic data — Helps to improve Windows and keep it secure, up to date, and working as expected — Sending required + optional data

You're sending required diagnostic data
As a part of using Windows, your device sends Microsoft a limited set of data that is necessary to keep your device and operating system secure, up to date, and working as expected.

Send optional diagnostic data — On
Help Microsoft improve your Windows experience and fix problems more quickly by sending us additional diagnostic data. This includes data about websites you browse, how you use apps and features, and enhanced error reporting.

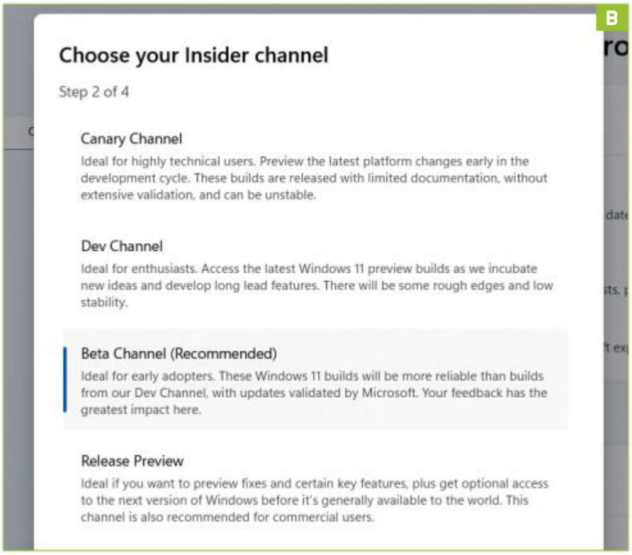
Your device will be equally secure and will operate normally even if you choose not to send optional diagnostic data.

Improve inking and typing — Off
Send optional inking and typing diagnostic data to Microsoft

Tailored experiences — Off
Let Microsoft use your diagnostic data for personalized tips, ads, and recommendations

View diagnostic data — Off
View your data in the Diagnostic Data Viewer

Delete diagnostic data
Clear diagnostic data that Microsoft has collected about this device


B

Choose your Insider channel

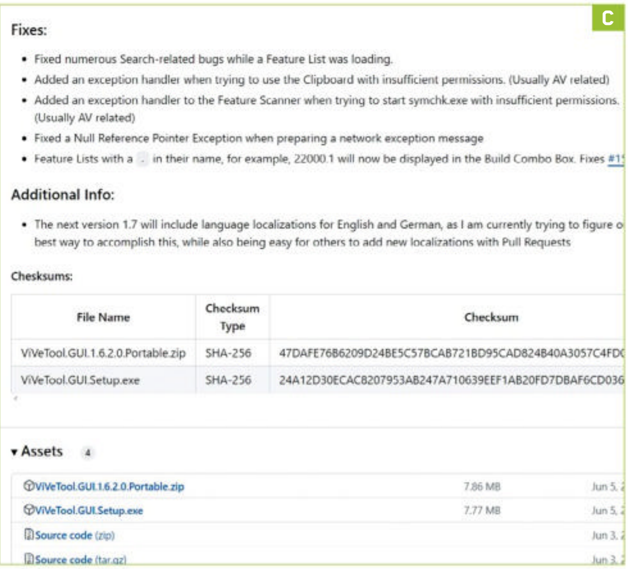
Step 2 of 4

Canary Channel
Ideal for highly technical users. Preview the latest platform changes early in the development cycle. These builds are released with limited documentation, without extensive validation, and can be unstable.

Dev Channel
Ideal for enthusiasts. Access the latest Windows 11 preview builds as we incubate new ideas and develop long lead features. There will be some rough edges and low stability.

Beta Channel (Recommended)
Ideal for early adopters. These Windows 11 builds will be more reliable than builds from our Dev Channel, with updates validated by Microsoft. Your feedback has the greatest impact here.

Release Preview
Ideal if you want to preview fixes and certain key features, plus get optional access to the next version of Windows before it's generally available to the world. This channel is also recommended for commercial users.


C

Fixes:

- Fixed numerous Search-related bugs while a Feature List was loading.
- Added an exception handler when trying to use the Clipboard with insufficient permissions. (Usually AV related)
- Added an exception handler to the Feature Scanner when trying to start symchk.exe with insufficient permissions. (Usually AV related)
- Fixed a Null Reference Pointer Exception when preparing a network exception message
- Feature Lists with a `.` in their name, for example, 22000.1 will now be displayed in the Build Combo Box. Fixes #1

Additional Info:

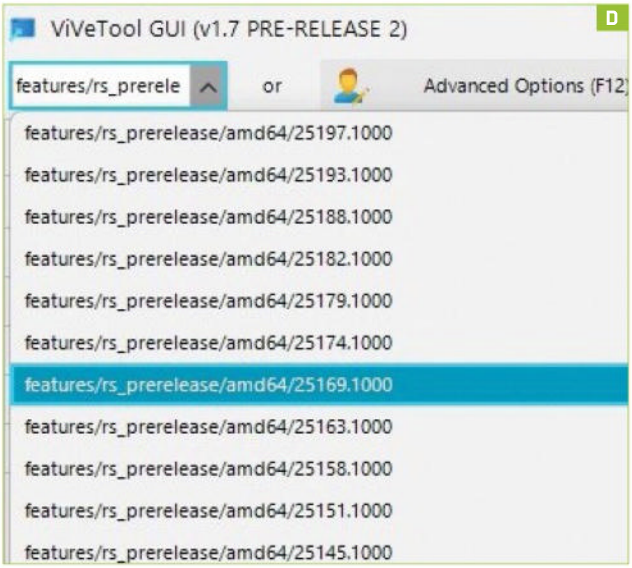
- The next version 1.7 will include language localizations for English and German, as I am currently trying to figure o best way to accomplish this, while also being easy for others to add new localizations with Pull Requests

Chesksums:

File Name	Checksum Type	Checksum
ViVeTool.GUI.1.6.2.0.Portable.zip	SHA-256	47DAFE76B6209D24BE5C57BCAB721BD95CAD824B40A3057C4FD
ViVeTool.GUI.Setup.exe	SHA-256	24A12D30ECAC8207953AB247A710639EEF1AB20FD7DBAF6CD036

▾ Assets 4

ViVeTool.GUI.1.6.2.0.Portable.zip	7.86 MB	Jun 5,
ViVeTool.GUI.Setup.exe	7.77 MB	Jun 5,
Source code (zip)		Jun 3,
Source code (tar.gz)		Jun 3,


D

ViVeTool GUI (v1.7 PRE-RELEASE 2)

features/rs_prerelease/amd64/25197.1000
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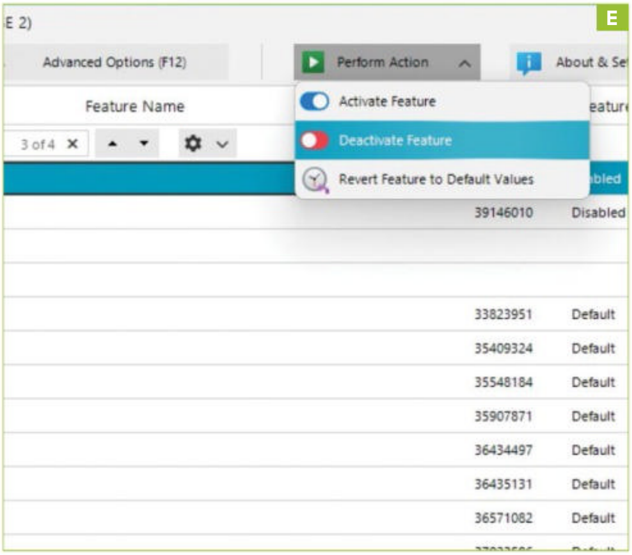
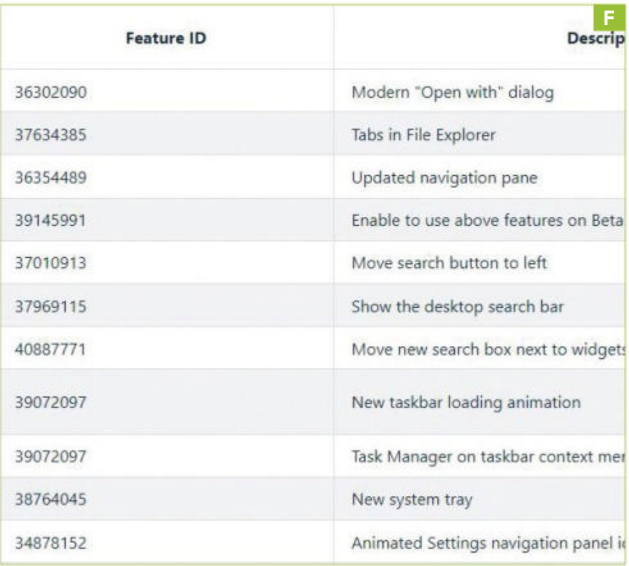
features/rs_prerelease/amd64/25145.1000


E

39146010	Disabled
33823951	Default
35409324	Default
35548184	Default
35907871	Default
36434497	Default
36435131	Default
36571082	Default


F

Feature ID	Descrip
36302090	Modern "Open with" dialog
37634385	Tabs in File Explorer
36354489	Updated navigation pane
39145991	Enable to use above features on Beta
37010913	Move search button to left
37969115	Show the desktop search bar
40887771	Move new search box next to widgets
39072097	New taskbar loading animation
39072097	Task Manager on taskbar context me
38764045	New system tray
34878152	Animated Settings navigation panel i

© MICROSOFT

LAB NOTES

JEREMY LAIRD, CONTRIBUTOR

Size matters, but not like that

What's the point of high-performance gaming laptops?

I'M NOT A huge fan of traditional gaming laptops. I want them to be good to the extent that I've run about 10 of them long-term, but they've all disappointed.

However, the last few months have given me a new perspective. It turns out I was using the wrong kind. I covered the excellent Asus ROG Flow X13 a couple of issues back. Now, I've had a brief spin with the HP Omen Transcend 14, and I find myself lusting after gaming laptops again.

Both systems share a thin-and-light philosophy. They don't aim to achieve desktop-like performance. Instead, they look for gaming chops. Those aren't genuine laptops in my view; they're portable PCs.

Instead, both the Asus ROG Flow X13 and HP Omen Transcend 14 are lovely devices just as laptops. They'd both be on my radar for a non-gaming device. But then, they throw gaming into the mix, and I'm smitten.

Much of the credit for this has to go to Nvidia. Its latest Ada Lovelace GPU architecture is a huge step up in terms of power efficiency, making decent gaming in an ultra-light form factor possible.

Both laptops are available with up to RTX 4070 Mobile graphics. Okay, that's not a beast of a GPU, but the hardware specs in terms of shader counts, if not clockspeeds, are beyond an RTX 4060 Ti desktop card.

Speaking of clock speeds, that's where you see the limitations of the form factor. The Asus has a 60W GPU spec, the HP 65W. That puts a cap on GPU frequencies, so neither of these laptops would be a good choice for maximizing bang for your buck.

But that would miss the point. What matters is getting a nice 1080p gaming experience. They're more powerful than the latest generation of handheld gaming PCs, but barely any less portable.

Sea of Thieves

HP's Omen Transcend 14 joins the ROG Flox X13 in redefining what works in a gaming laptop.

They're also not all that expensive. The Asus can be had with an RTX 4060 for under $1,500, for instance, and it's only slightly slower than the top-spec version with the 4070. If you ask me, these sub-1.5kg are what mobile gaming is all about.

GUY COCKER

Editor-in-Chief

What to make of news that Samsung and LG have decided to stop fighting each other for OLED display dominance, due to the threat from China?

China is already on the way to forcing Samsung and LG out of the LCD display market. Now, it's moving into OLEDs. LG and Samsung remain dominant in OLED manufacture, but the trend lines are obvious. In 2018, China had a few percentage points of the market, with the rest almost all owned by that South Korean pairing.

By the first half of 2023, China hit nearly 25 percent OLED market share. You'd expect China to be the dominant player in OLED in about five years. That's scary for LG and Samsung, and explains why they've decided to bury the OLED hatchet.

I'm not sure this is good news for OLED PC monitors. They're rapidly improving thanks to competition between LG and Samsung, each with its own bespoke take on OLED, with Samsung's QD-OLED panels having advantages and weaknesses—LG's WOLED tech likewise.

We've seen some decent advancements in OLED panel tech, with second-gen OLED PC monitors like Samsung's Odyssey OLED G9 G93SC and the Asus ROG Swift OLED PG34WCDM offering advances over first-gen models. Take that away, focus on a race to the bottom in a price war, and it's not obvious the outcome will be better PC monitors.

© HP

Is Asus's new value-orientated 1440p monitor all the gaming panel you'll ever need?

REPUBLIC OF GAMERS

Editor's Pick: Asus ROG Strix XG27ACS

The monitor you've been waiting for?

A 27-INCH 1440p panel has been the sweet spot for gamers for as long as I can remember. Arguably, that hasn't changed. Okay, I'd favor a 34-inch ultrawide version of the 1440p thing. But at the very least, a high-refresh 27 incher remains one of the most popular and relevant monitor form factors.

Panels in this category that hit the basic spec points of minimum 144Hz refresh and an IPS panel can now be had for under $200. But if you add a couple of provisos, let's say minimum 400 nits brightness and basic HDR support from a brand you've heard of rather than some random panel with no provenance, you're looking at around $230 to $250 minimum.

The Gigabyte G27Q can be had at the lower end of that range, and ticks each and every box. That's a lot of monitor for the money, and it makes life difficult for the likes of the Asus ROG Strix XG27ACS. A couple of years ago, its $299 real-world pricing would have looked super appealing. Today, it's trickier.

Along with the aforementioned 27-inch, IPS, HDR400 specs, it rocks a 180Hz refresh, 1ms GtG response, and USB-C with power delivery. That's more comprehensive than the 2ms, 144Hz Gigabyte, which lacks USB-C connectivity. However, the Strix XG27ACS's USB-C port can only deliver 7.5W of power, so you can forget keeping a laptop juiced up in a single-cable scenario—that's not enough.

That minor snafu aside, this is one heck of a monitor. For starters, it's beautifully calibrated. In default SDR mode, it looks great—vibrant, punchy, and accurate. But most impressive is this panel's performance with HDR enabled.

Oddly, I'm not actually talking about how it handles HDR visuals. This is an HDR400 panel with no local dimming, so you're only getting the most basic HDR support. Instead, it's the way SDR content is rendered when you enable HDR. It's the closest I've seen an affordable HDR-capable LCD monitor get to perfect SDR calibration in HDR mode.

It's all too common to have wonky SDR colors and contrast in HDR mode on so many monitors. The upshot is that you have to keep jumping back and forth between modes, but not with this Asus Strix screen. You can run it in HDR mode all the time, and everything just looks right.

That rare victory aside, this monitor's other party piece is response. It's as quick an IPS panel as I've seen. What's more, the OSD menu offers 20 granular levels of pixel overdrive, so you can decide just how much overshoot you are willing to tolerate in return for faster response.

That said, even with the overdrive maxed out, the overshoot and inverse ghosting isn't too bad. This is just a rapid display, but it's not as rapid as an OLED monitor of the same size and resolution, and that begs an immediate corollary, which is whether such OLEDs represent value by comparison.

You're talking roughly $800 for a 27-inch 1440p OLED gaming panel—they definitely aren't three times the experience. All of that means this monitor gives you almost everything you could ask for.

Its only slight misstep is that under-powered USB-C interface. For sure, if you have no intention of hooking up a laptop, it arguably doesn't matter. But it feels like a bit of a gimmick to advertise a display with USB-C power delivery only to find it's limited to a fairly pointless 7.5W. **–JL**

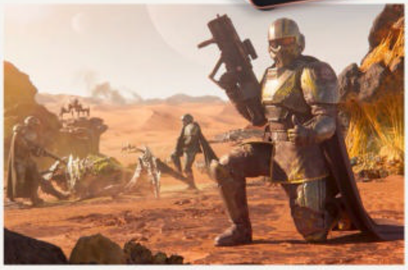
$299, www.asus.com

Reviewed...

74 MSI GeForce RTX 4070 Ti Super 16G Ventus 3X

76 AMD Radeon RX 7600 XT

78 AMD Ryzen 7 8700G
80 Dough Spectrum One
82 Lenovo Legion Go
84 Hyte Y40
87 2TB Crucial T500 M.2 PCIe 4.0 SSD
88 32GB Corsair Dominator Titanium DDR5
89 Benq X3100i



90 Helldivers 2
92 WhatsApp vs Signal

© ASUS, SONY INTERACTIVE ENTERTAINMENT

IT GENUINELY FEELS like we're turning a corner in the world of PC gaming. Finally, we're leaving the shackles of 1080p behind, and heading to the clear, glossy-coated clarity of 1440p and beyond. The likes of the RTX 4070 Super and 4070 Ti Super really do cement that notion. In fact, the entire Super range with either identical pricing and increased hardware, or similar hardware and significantly reduced pricing, is definitely a good thing.

So then, what card do we have on the chopping block this time? Well, this, as you've probably already spotted, is the MSI GeForce RTX 4070 Ti Super 16G Ventus 3X (seriously MSI, we need shorter names, come on now). Unfortunately, the 4070 Ti Super doesn't quite have the same glamor as the other GPUs in Nvidia's lineup, as it lacks a stock Founders Edition variant, so if you're on the hunt for a clean-looking black fan solution, you're going to be looking at other models, which is a shame. That said, there are a number of cards out there that look the part, and the MSI variant here certainly does that.

Before we get there, though, let's talk about the past, namely how the 4070 Ti came to be. At the initial launch of the RTX 40 series cards, Nvidia pitched not one, but two RTX 4080s. One, the full-fat 16GB VRAM, 9728 CUDA core monster we all know and love, and the other a 12GB variant, complete with fewer CUDA cores (and hardware, for that matter). Frankly, it was a bit ridiculous, and was inevitably going to lead to confusion down the line. The community and media revolted, and Nvidia pulled the launch and rebadged all those 12GB variants with the 4070 Ti moniker instead a few months later.

The problem was that the 4070 Ti was a bit of a mediocre jack of all trades—slightly overkill for 1440p, and a bit 'meh' for 4K, as it lacked the necessary VRAM to give it any length of future-proofing, leading many analysts to be disappointed with it (ourselves included).

Fast-forward a year, and the Super cards are announced, along with the Ti Super. Interestingly, each card represents a significantly different strategy to one another. The standard 4070 Super features the same VRAM, and the same price, but 20 percent more hardware. The 4080 Super features five percent more hardware, and a $200 price drop, yet more interestingly, the Ti Super bridges the gap with 10 percent more hardware, the same price, and, you guessed it, a bump up to 16GB of VRAM—arguably what it should have launched with initially.

Although it's given the original 4070 Ti an incredibly short life cycle of just over a year, it does mean that we finally have a mid-range(ish) card that performs well at 4K, particularly if you're looking to go above that all-important 60 fps threshold.

As far as performance is concerned, the 4070 Ti Super performs admirably at 4K, nailing 102 fps in *Far Cry 6*, 86 in *Assassin's Creed: Valhalla*, and 61 in *Cyberpunk* with ray tracing and DLSS turned on with our test-bed. Overall, it nets an average frame rate of around 90 at 4K, and 174 at 1080p. The 4070 Super also does fairly well here, with 161 fps at 1080p on average, and 75 at 4K. That's mildly problematic, particularly given the $200 price difference between the two.

The RTX 4070 Ti Super is an interesting card. In isolation, it's an impressive unit with a comfortable hardware bump and a ton of extra VRAM to provide some solid 4K futureproofing. On the flipside, compared even to Nvidia's own cards, the difference between it and the new 4070 Super is far more blurred than it was before, which makes it challenging to recommend, at least in the short term. If you pick one up today, you'll be happy, although a bit poorer, but in the future? Well, you might be onto a winner. **–ZAK STOREY**

BENCHMARKS

	Nvidia GeForce RTX 4070 Ti Super	Nvidia GeForce RTX 4070 Super
3D Mark: Speedway (Index)	**6,093**	5,024
3D Mark: Port Royal (Index)	**14,893**	12,859
Max Power Draw (Watts)	531.2	**502.3**
Max Temperature (Celsius)	**72**	78.9
Total War: Three Kingdoms @ 1080p (avg fps)	**184**	173
Final Fantasy XIV @ 1080p (avg fps)	**225**	211
Far Cry 6 @ 1080p (avg fps)	**151**	136
Assassins Creed: Valhalla @ 1080p (avg fps)	**163**	152
Cyberpunk 2077 @ 1080p (avg fps)	**145**	132
Total War: Three Kingdoms @ 4K (avg fps)	**71**	53
Final Fantasy XIV @ 4K (avg fps)	**128**	110
Far Cry 6 @ 4K (avg fps)	**102**	83
Assassins Creed: Valhalla @ 4K (avg fps)	**86**	74
Cyberpunk 2077 @ 4K (avg fps)	**61**	55
Avg fps @ 1080p	**173.6**	160.8
Avg fps @ 4K	**89.6**	75
Avg fps per $ spent @ 4K (Index)	0.11	**0.13**

Best scores in bold. Our test bed consists of an Intel Core i9-14900K, 32GB of Corsair Dominator Titanium @ 7200, Corsair H150i AIO, and an Asus Z790 Dark Hero. All tests performed at 1080 & 4K, avg fps recorded, RTX & DLSS is enabled in Cyberpunk. Power Draw and Temperature recorded during Port Royal benchmarking.

VERDICT

8

MSI GeForce RTX 4070 Ti Super 16G Ventus 3X

+ **AN ABSOLUTE TROOPER** Strong 4K performance; Good thermals; Big upgrade on last gen; More VRAM.

− **A DRUNKEN STUPOR** Pricing still a bit high; Lack of a dramatic computational bump hurts it compared to the 4070 Super.

$599, www.nvidia.com

SPECIFICATIONS

Architecture	Ada Lovelace
Manufacturing Process	TSMC 4N 5nm
CUDA Cores	8,448
ROPs	112
RT Cores	66
Tensor Cores	264
Memory	16GB GDDR6X
Memory Bus	256-bit
TDP	285W

MSI GeForce RTX 4070 Ti Super 16G Ventus 3X

Iterative change and 4K dominance

GEFORCE RTX
msi
msi
msi
msi

The 4070 Ti Super is a good 4K card, even though it's still not good on value for money.

AMD Radeon RX 7600 XT

As cost-effective as an RTX 4080 Super

THIS IS NOT a great card to be writing about, unfortunately. AMD's low-end budget model is something of an oddity. It comes with a rather lackluster launch all things considered—on its own, solo, in Q1. Where Nvidia is launching multiple Supers, and redefining its entire GPU range, AMD has launched this. Admittedly, Team Red did provide us with the more impressive 7800 XT and 7700 XT late last year, but those had a bit more gumption than this thing does.

Let's take top-line stats first. The RX 7600 XT is based off of the RDNA 3 architecture, manufactured by TSMC on its slightly older N6 manufacturing process, and features a 7nm transistor size. By default, it clocks in with 2,048 stream processors and touts a maximum clock speed on paper of 2,755 MHz. On top of that, you get 16GB of GDDR6 VRAM on a 128-bit bus, and it's rated at 190W of power. It's also on a PCIe 4.0 x8 bus, (although we suspect this is more to do with marketing, as that's effectively the same as a PCIe 3.0 x16, but allows you to label it up as a PCIe 4.0 card).

The big difference with the RX 7600 that launched back in May 2023? Aside from software-level changes we've seen across the board with the XT hardware, VRAM, clock speed, power draw, and a price bump? That's it, really. Clock speeds have increased by 100 MHz, you get 16GB of VRAM instead of 8GB, an extra 25W of TBP, and the RRP is up by $60.

It's a challenging sell, and that's before we get to the performance figures. They don't make for good reading. At 4K, average frame rates sit at 29. Most titles float around the 30 fps mark, but anything with ray tracing enabled hammers it into the ground, even with AMD's upscaling enabled. It's better suited to 1080p, with average frames sitting comfortably at 76.4 fps in our testing.

Here's the thing. Yes, games have come a long way in the last eight years or so, but you could have easily spent $330 back then and still got a card that performs similarly to this thing at 1080p. Okay, inflation has hit us hard over the years, but you've got to question the logic. Average FPS per $ spent at 4K sits at just 0.09. Yes, this isn't really suited for that (despite having the same VRAM as some of its larger competition), but it provides us with an insight into its value. When it's less cost-effective than an RTX 4080 Super, we've got to start questioning the logic, particularly when the only thing that's changed is that VRAM, and no other internal hardware.

As for temperatures and power draw, it performs similarly poorly. Maximum power draw under load was 491.5 W, and temp sat at 81.2 C, putting it in line with an RTX 4070 Super—except again, that's a card that produces more than twice as many frames as this does.

It's a shame, because AMD's dominance in the CPU market, particularly around efficiency, cost, and performance, is starting to shine. By comparison, its GPU side of the business is still some years behind. Is the 7600 XT a good card, compared to other offerings at this price? Not really. It pains us to say it, as we need competition in the GPU market and choice for the consumer, but right now, you'd be much better off with an RTX 4060 Ti. It's $30 cheaper, and performs 35 percent faster. That's the reality. **–ZAK STOREY**

BENCHMARKS

	AMD Radeon RX 7600 XT	Nvidia GeForce RTX 4070
3D Mark: Speedway (Index)	3,101	**4,532**
3D Mark: Port Royal (Index)	6,124	**11,298**
Max Power Draw (Watts)	**491.5**	499.7
Max Temperature (Celsius)	81.2	**73.7**
Total War: Three Kingdoms @ 1080p (avg fps)	88	**147**
Final Fantasy XIV @ 1080p (avg fps)	105	**169**
Far Cry 6 @ 1080p (avg fps)	69	**123**
Assassin's Creed: Valhalla @ 1080p (avg fps)	75	**117**
Cyberpunk 2077 @ 1080p (avg fps)	45	**100**
Total War: Three Kingdoms @ 4K (avg fps)	22	**41**
Final Fantasy XIV @ 4K (avg fps)	43	**88**
Far Cry 6 @ 4K (avg fps)	33	**67**
Assassin's Creed: Valhalla @ 4K (avg fps)	31	**56**
Cyberpunk 2077 @ 4K (avg fps)	16	**45**
Avg fps @ 1080p	76.4	**131.2**
Avg fps @ 4K	29.0	**59.4**
Avg fps per $ spent @ 4K (Index)	0.09	**0.10**

Best scores in bold. Our test bed consists of an Intel Core i9-14900K, 32GB of Corsair Dominator Titanium @ 7200, Corsair H150i AIO, and an Asus Z790 Dark Hero. All tests performed at 1080 & 4K, avg fps recorded, RTX & DLSS is enabled in Cyberpunk. Power Draw and Temperature recorded during Port Royal benchmarking.

VERDICT

6

AMD Radeon RX 7600 XT

+ XTRA XTRA READ ALL ABOUT IT Decent 1080p gaming performance; Manageable temperatures; Good software suite.

− XTREMELY DISAPPOINTING Mediocre performance across the board; Poor price to performance; Power hungry and hot; 16GB of VRAM is pointless; Price hike on last gen: No major hardware upgrades.

$329, www.amd.com

SPECIFICATIONS

Architecture	RDNA 3
Manufacturing Process	TSMC 6N 7nm
Stream Processors	2048
ROPs	64
RT Accelerators	32
AI Accelerators	64
Memory	16GB GDDR6
Memory Bus	128-bit
TDP	190W

GIGABYTE
GIGABYTE
GIGABYTE
HDMI
HDMI
DP
DP

Just don't buy it.

AMD's new APU uses the same Phoenix silicon already seen in laptops and handhelds.

AMD Ryzen 7 8700G

1080p gaming with integrated graphics? Hell, yes

IN CASE YOU HAVEN'T noticed, graphics cards are expensive, but AMD has a solution. Maybe. The Ryzen 8000-series APUs include the most powerful integrated graphics ever, and this Ryzen 7 8700G is the top chip of the lot. The basic idea? You won't need a graphics card for entry-level 1080p gaming.

This is the same Phoenix chip that first appeared in laptops about a year ago, and more recently in handheld gaming PCs. The latter application is intriguing. If Phoenix can deliver decent performance in a power-restricted handheld form factor, what is its fully unleashed potential in a desktop?

This $329 eight-core Ryzen 7 8700G with Radeon 780M graphics is joined by the $229 six-core Ryzen 5 8600G with 760M graphics, the $176 hybrid six-core Ryzen 5 8500G, and four-core 8300G. The latter two come with 740M graphics and a mix of Zen 4 and Zen 4c cores. It's a full range of CPUs, then. But can this range-topper deliver on that 1080p promise?

Yes it can. The Radeon 780M IGP of the 8700G is enough to play all of our benchmarked games at 1080p. Forget that low-resolution, 720p, minimum detail nonsense. We're talking 1080p with at least medium settings.

Okay, you can't expect to run *Alan Wake 2* or *Cyberpunk 2077* with the ray tracing eye candy turned up, but then that's stressful on just about any graphics card. What our testing does prove is that less demanding games, including online shooters or MOBA titles, will run butter-smooth on the 8700G.

Don't forget about AMD's suite of technologies, including FSR and Fluid Motion Frames. These are well worth turning on if you're struggling to hit that all-important 60 fps threshold. *F1 22*, *Tiny Tina's Wonderlands*, and *Far Cry 6* all ran above 60 fps at 1080p with medium to high settings with FSR enabled. Hoorah!

Of course, all but the cheapest GPUs will have it beat. But GPUs like the RTX 4060 and RX 7600 will add a lot of cost to your rig and, depending on the games you play, may simply be overkill.

Anyway, while we're happy to shout about the gaming performance of the 8700G's integrated GPU, its all-round CPU performance is slightly less impressive. This is still a quick CPU with eight proper AMD Zen 4 cores running at up to 5.1GHz, but gamers with discrete graphics cards should look towards one of AMD's 7000-series CPUs, or even something like the still excellent Ryzen 7 5800X3D if you're sticking with AM4. That's without even mentioning the plethora of Intel 12th, 13th, and 14th Gen options. They'll all give you better bang for your buck if you're not going to lean on this APU's integrated GPU.

But hang on, what about the feature in Phoenix that's not available in any of AMD's conventional desktop CPUs? Yup, this APU has an NPU or AI accelerator. AMD says its NPU and software development kits deliver inference model processing to the likes of the Adobe suite and DaVinci Resolve.

For now, the reality is that there are few compelling real-world applications. That will almost certainly change in future, but it's an open question whether it will happen in time to be really relevant to this APU, and indeed if Phoenix's AI performance will be up to the job when that day comes.

The 8700G may not be the all-round wonder chip we'd hoped for, but it's great to see AMD offer compelling options for long-suffering casual PC gamers. The 8700G is also a decent chip for a daily driver PC, thanks to its excellent power efficiency and undemanding cooling requirements. It's just not a compelling option if you're primarily looking for a CPU for productivity or creativity purposes. **–CHRIS SZEWCZYK**

VERDICT

8

AMD Ryzen 7 8700G

⊞ **RISING SUN** Best ever desktop integrated graphics; Excellent power efficiency.

⊟ **BURNED OUT** Not the best option for use with a discrete GPU; Lacks PCIe 5.0.

$329, www.amd.com

BENCHMARKS

	AMD Ryzen 7 8700G	AMD Ryzen 7 5700G	AMD Ryzen 7 7700X	Intel Core i5-14600K
Cinebench R23 (points)	17,587	13,989	19,565	**24,249**
Blender (samples per minute)	78	65	86	**102**
4K video encoding (fps)	81	61	91	**111**
F1 2022 (fps)	**86**	35	N/A**	17
Total War: Warhammer III (fps)	**190**	22	N/A**	6

Best scores are in bold. **The AMD 7700X does not have a gaming capable integrated GPU

SPECIFICATIONS

Architecture	Zen 4
Cores / Threads	8 / 16
Base / Boost Clock (GHz)	4.2 / 5.1
Integrated Graphics	Radeon 780M, 12 CU, 2.9GHz
Lithography	TSMC 4nm
L2 + L3 cache	24MB
PCIe lanes (Total/GPU)	20 / 8
TDP	65W
Boxed cooler	AMD Wraith Spire

The revised Spectrum One has Gorilla Glass with an anti-abrasion finish.

Dough Spectrum One

As stunning as Dough's original glossy display

© UNSPLASH

FORMERLY KNOWN as Eve, Dough has had a shaky start. The internet is littered with tales of product non-delivery and delayed refunds, but it's hanging in there with this revision of its 27-inch 4K gaming panel.

It started off as a fairly conventional 4K monitor with a matte anti-glare coating, then it went glossy. Now, we've got a further iteration, using Corning's Gorilla Glass with DXC. The glossy version was a game changer; it made a huge difference to the contrast levels, so it's exciting to see what the new Corning Gorilla Glass version—the first gaming monitor to offer it—can deliver.

The pitch is that it will handle reflections better and offer more robust anti-abrasion protection, while maintaining the contrast advantages of a more conventional glossy panel. The anti-abrasion bit is why Gorilla Glass is found in so many smartphones—after all, they spend much of their lives jammed into the pockets of careless owners or skittering across pavements and tabletops.

Then again, Apple goes for edge-to-edge glass on its desktop displays, so Dough is hoping to tempt designers as well as gamers. Anyway, the first good news is that Dough's newest monitor is available in retail. You don't have to brave the company's customer service lottery; you can simply buy it online from a third-party retailer.

The other welcome revelation is that this is a gorgeous monitor. It's bright, clear, and responsive. The contrast is definitely superior to a matte anti-glare coating, ditto clarity, which always slightly suffers with matte solutions.

The DisplayHDR 600 rating and peak luminance of 750cd/m^2 means that it's very punchy, and has tolerable HDR. It looks stunning in *Cyberpunk 2077*, *FC24*, and *Baldur's Gate 3*. What it isn't is wholly different from the previous glossy version of the same screen. Side by side, you'd be hard-pushed to tell the difference.

Okay, this Gorilla Glass version is physically tougher, but do you need that from a desktop monitor, as opposed to a phone or tablet? Right now, the original glossy version is on sale, again from B&H Photo, for $600, though you will still need a $100 stand unless you already have a monitor arm that will fit it. That makes this glass version almost $900 all in, and the standard glossy $700.

With both versions, you get a built-in USB hub that either works via USB Type-B or Type-C and contains a KVM switch. It will also deliver 100W of power over that Type-C connection. That makes it one of those one-cable-to-rule-them-all monitors for plugging into most laptops, though not gaming laptops—that 100W power limit isn't going to keep a discrete GPU fed in a modern machine.

Regardless, $900 is a lot of money for a 27-inch 4K monitor. The latest LG Ultragear 27GR93U, with its dimmer 144Hz 4K panel, is still $630, so there is some parity with the original glossy Spectrum One. For the Gorilla Glass version, it's hard to see enough of an improvement over its excellent glossy sibling to make it worth the expense.

Maybe if, like me, you have two young sons, you might be grateful for a tougher screen. Anything that can stand up to that surely has some value. But then, high-velocity toddler-propelled missiles are a somewhat niche concern.

If all that makes this new variant of the Dough Spectrum One a slightly tough sell, it does also get us excited for the future. Dough is working on an OLED monitor that wil also be offered with Gorilla Glass. Now, *that* we'd like to see. **–DAVE JAMES**

VERDICT
8

Dough Spectrum One

⊞ **SHINY, SHINY** Beautiful IPS panel; Gorilla Glass hugely improves visuals.

⊟ **WHINEY, WHINEY** Very expensive; Not hugely better than the glossy version.

$900, www.dough.tech

SPECIFICATIONS

Size	27-inch
Panel type	IPS
Native resolution	3840 x 2160
Refresh rate	144Hz
Response	1ms (overdrive)
Inputs	2x HDMI 2.1, 1x DP 1.4a, USB Type-C
HDR	HDR10, DisplayHDR 600
Peak luminance	750 cd/m^2
Features	USB 3.2 Gen2 hub, 100W PD, FreeSync Premium Pro, G-Sync Compatible

A large 8.8-inch screen and clip-on controllers are the signature features.

Lenovo Legion Go

A handheld gaming PC, just on a larger scale

FOUR YEARS AGO, gaming handhelds were barely on the radar. Today, there are numerous options from some of the biggest manufacturers around. You can now add Lenovo to that list, thanks to what is one of the sleekest-looking gaming handhelds so far.

The Lenovo Legion Go is an awfully good-looking device. It immediately feels like $700 well spent. It's mostly made up of an enormous 8.8-inch glossy touchscreen. This is the Go's most impressive feature by far: it's big, vibrant, responsive, and gives the impression of an almost edge-to-edge display.

It's not quite that, however, as the panel doesn't extend all the way to the edges of glossy layer on top. But it's still an entirely different beast to the compact Ayaneo Air 1S's 5.5-inch screen. Once you start gaming on it, it's engrossing in a way a more compact handheld can't be.

As a result, the Go is a significantly larger device than most handhelds to date. Even the Steam Deck looks pretty compact by comparison. It's not lightweight, either. Our top pick for the best handheld gaming PC today, the OneXPlayer OneXFly, weighs 580 grams, so the Go's 854 grams with controllers or 640 grams without is noticeably heftier to the point where it's a little bit uncomfortable to wield single-handedly.

Unlike most other handhelds, the Go offers detachable controllers. Similar to those on the Nintendo Switch, to detach you hold a button and pull down. To reattach, just line each one up and click into place.

Speaking of the controllers, Lenovo has made a big fuss about the Go's FPS mode. It turns the right-hand controller into a makeshift mouse. I tried it with *Baldur's Gate 3* and *Frostpunk*, and didn't entirely get along with it. But it sure beats navigating Windows via prodding the screen, and it does makes games like *Frostpunk* much more playable.

But all that isn't actually why I like the Go's detachable controllers. No, they're key to the Legion Go's comfort, thanks to the little stand on the rear of the device, much like a Switch, turning the Legion Go into one of the comfiest handhelds I've used to date.

The small stand built into the rear of the Go's chassis unfolds to keep it upright on a desk. It's adjustable, too. Unclip the controllers, and you can sink into your seat and genuinely relax while playing. This is absolutely the best way to play games like *Baldur's Gate* on Legion Go.

But what about gaming performance? The specifications and screen can seem a bit imbalanced. It's powered by the same AMD Ryzen Z1 Extreme APU as the ROG Ally. It comes with an RDNA 3 GPU featuring 12 compute units, which is plenty of power for many indies and low-rent games like *Sonic*, and even a few big hitters that play on lower-spec hardware. However, it's not going to get you far with a 2560 x 1600 resolution at 144Hz in many popular or recently released games.

You'll most likely find yourself setting the screen to a more moderate 1920 x 1200 resolution for gaming. Running interpolated like this works well on what is a pretty compact screen, even if it's large by handheld standards. Still, games like *Baldur's Gate 3* are an exercise in flicking as many performance-friendly switches as possible. Reduce the resolution, turn on FSR, lower the presets—you need the lot to score playable performance.

So like other handhelds, it's indie titles that suit the Go best. For me personally, my Steam Deck is my indie machine, it's the reason I've found time to play half of the games in my backlog. If anything, you can enjoy those games even more on the Go. **–JACOB RIDLEY**

VERDICT

8

Lenovo Legion Go

+ **ON THE GO** Glorious screen; Detachable controllers are ace; Awesome for indie games.

− **GOING, GOING, GONE** Heavy and big; Native resolution not a goer in most games.

$700, www.lenovo.com

SPECIFICATIONS

Processor	AMD Ryzen Z1 Extreme
GPU	Radeon 780M (12CU | RDNA 3)
CPU	8 cores/16 threads (Zen 4)
RAM	16GB LPDDR5
Storage	512GB/1TB NVMe SSD Display: 8.8-inch, 144Hz IPS
Ports	USB4 Type-C x2, 1x 3.5mm jack, MicroSD card reader
Connectivity	Wi-Fi 6E, Bluetooth 5.1
Battery	49.2WHr
Weight	854g (with controllers)
Dimensions	40.7 x 298.83 x 131mm

BENCHMARKS

	Baldur's Gate 3 Average fps	Baldur's Gate 3 Minimum fps
Low preset, no FSR, 2,560 x 1,600	26	8
Low preset, no FSR, 1,920 x 1,200	44	34
Low preset, FSR Performance, 1,920 x 1,200	55	33

One of the most beautiful mid-towers out there.

Hyte Y40

Traditional design meets Hyte

THERE'S SOMETHING magical about this case, and we can't quite place our finger on it. It might be the glass paneling, the multitude of cooling options, or the simple, yet elegant PC building features included with the Y40, but it may well be one of the best ATX tower gaming PCs money can buy right now. That's a bold claim, we know, but this is truly something else.

Hyte is an incredibly interesting company when it comes to case design. It hasn't been around for any particularly long length of time, and yet it has taken the PC enthusiast space by storm. The Y60 and Y70 Touch, complete with their fishbowl designs, integrated displays, and intuitive build features, really did break new ground, which is perhaps unsurprising from a subsidiary of iBuyPower. After all, if anyone's going to be able to build a decent chassis, it's the company that has spent the last decade or so building custom rigs in all manner of cases.

The Y40, then, is a bit of a departure from those two flagship cases we've covered in depth in the past. Indeed, it follows a far more traditional style. It's the big rectangular tower box we've all come to know and love, but with a few neat tweaks to accentuate your build without compromising on cooling.

One case that definitely comes to mind with this is NZXT's (almost ancient at this point) H510 Elite. Complete with solid glass front and side panels, it looked gorgeous, and really lets you show off your build and RGB in the process. However, there was one major caveat: cooling. Hyte has taken that style, and instead of allowing you to mount fans in the front, it has merged that design with the likes of its fishbowl style, giving you access to two side intakes, along with a 140mm vent in the bottom of the chassis under the PSU shroud to allow you to pull air directly from the base of the unit (one that's well-lifted, thanks to a good inch of ground clearance).

Similarly to the Y60 and the Y70, the Y40 also limits you slightly with vertical GPU mounting only, unless, of course, you have a half-height card. Yup, included in that $150 price point is a PCIe 4.0 riser and support for up to a four-slot card. There's plenty of space for ventilation here too, although you might want to shy away from some of the thicker RTX 4090s. Again, thanks to that grill PSU cover and bottom 140mm fan, it's far less toasty than in traditional cases like this.

Speaking of cooling, on top of the two 140mm side vents and the 140mm in the base of the chassis, there's also support for three 120mm fans in the roof, and one 120mm in the rear of the case as well, with radiator support following suit for all of the top-side fan mounts.

As for flaws? Well, cable management solutions aren't super glamorous here. You've got your usual array of cable tie mounting hooks, but that's about it. Far more annoying than that is the lack of a suitable fan controller—not even a dumb one. It's the only thing this chassis is currently missing that would really improve things. It doesn't need to be fancy, have RGB integration, or connect to Hyte's Nexus tech—all it needs is to merge multiple PWM headers into one, and provide power as it does so.

That said, this is a really minor misstep for what is an otherwise beautiful chassis. Combine that with the insane amount of color variants out there, and again that $150 price point, and this is without a doubt one of the most beautiful mid-towers out there right now. **–ZAK STOREY**

VERDICT
9
KICK ASS!

Hyte Y40

+ HYTECH Incredible aesthetics; Flexible cooling; Easy to build in; Solid pricing; Included PCIe 4.0 riser.

- TAKE A HYTE No fan controller; Cable management could be better.

$150, www.hyte.com

SPECIFICATIONS

Motherboard Support	ITX, Micro-ATX, ATX
2.5-inch / 3.5-inch Support	2x 2.5 / 1x 3.5-inch
Max Radiator Support	280mm Side, 120mm Rear, 360mm Roof
Fan Support	2x 120/140mm Side, 1x 120mm Rear, 3x 120mm Roof, 1x 120/140mm bottom
Dimensions	17.3 x 9.4 x 18.6 - inches
Graphics Card Clearance	16.6 x 3.7 - inches
CPU Tower Clearance	7.2 - inches
Warranty	Three Years

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2TB Crucial T500 M.2 PCIe 4.0 SSD

The best budget 4.0 drive?

THIS MIGHT JUST BE the best-value M.2 PCIe 4.0 SSD we've found—one that not only delivers big on the storage per $ front, but doesn't sacrifice performance while it does it. Yep, we're talking about the Crucial T500. We might not have been quite as impressed with the T700 Pro, but the T500 hits all the right marks.

At its heart, it's a super-speedy PCIe 4.0 drive, with sequentials listed at 7,400 and 7,000 MB/s and random read/write IOPS at 1,180K / 1,440K respectively. You can pick one up in two variants, either with or without a heatsink, and it features an impeccable 1200 TBW endurance rating and a five-year warranty.

The NAND flash at its core is the real showpiece, however. It's powered by Micron's 232-layer NAND Flash tech—according to Micron, it's 35 percent denser than the best-competing products out there (at least at time of release, debuting back in early 2023, and landing in products at the tail end of last year), and gives it an edge when it comes to TLC density per square millimeter, putting in an impressive 14.6Gb/mm2, or a 24.6 percent improvement on the last generation of Micron's NAND Flash. In fact, it allows for 2TB of total storage per packaged chip. It also significantly cuts down on latency in the process.

Crucial has built this with a very specific purpose in mind, and that's to take the fight to the PS5 expandable storage front. PlayStation Plus might be leading the way, but for those not so keen on streaming the latest titles, localized storage is still key, and it's a hot market.

The T500 is a single-sided M.2 design, with the major components on one side of the SSD. Complete with a low-profile heatsink to fit in the PS5's M.2 slot, it allows Crucial to cool the SSD without having to worry about any components situated in the underside. It's also running off of the Phison E25 controller, partnered alongside 1GB of LPDDR4 for fast short-term cache transfers, with the 232-layer TLC and solid sustained transfers over larger file sizes.

All this provides decent performance results. CrystalDisk saw sequential reads at 7,879 MB/s with reads coming in at 6,783 MB/s, 4K random reads and writes also sat fairly high at 92 and 331 MB/s respectively, and latency remained low in AS SSD's access time too, topping out at 0.018 and 0.017 ms. The temperature stayed solid at a balmy 72 C, showing that heatsink working hard.

If you do decide to grab one, make sure you know ahead of time if you want the heatsink. Unlike some of its competitor drives, it's difficult to remove the heatsink from the T500 without damaging the componentry inside. There are no screws here, or easy access options to take the drive out after the fact.

Crucial's T500 is an impressive drive. It can hold its own in quick burst sequentials, and over progressive file transfers continues to maintain solid file transfer speeds. Combine that with the low-profile design and reasonable price, and whether you plan to slam this in a PS5 or a PC is a moot point. Either way, you're going to be left with an incredibly rapid and dependable SSD. **–ZAK STOREY**

VERDICT
9
KICK ASS!

2TB Crucial T500 M.2 PCIe 4.0 SSD

TITANOSAURUS INDICUS Impressive performance; Very affordable; High-tech TLC; Single side design.

TURKEY Can't easily remove heatsink.

$149, www.crucial.com

BENCHMARKS

	2TB Crucial T500 Pro PCIe 4.0 M.2 SSD	2TB Gigabyte Aorus Gen5 12000 PCIe 5.0 M.2 SSD	1TB WD Black SN770M PCIe 4.0 M.2 SSD
AS SSD Sequential - Read / Write (MB/s)	5,631 / 4,455	**8,970 / 9,948**	4,550 / 3,818
AS SSD Random 4K - Read / Write (MB/s)	81.37 / 277.75	**86.65 / 289.12**	67.31 / 264.00
AS SSD Access Time (ms)	0.018 / **0.017**	0.017 / 0.037	**0.017 / 0.017**
CrystalDiskMark Sequential QD32 Read / Write (MB/s)	7,879 / 6,783	**12,353 / 11,598**	5,222 / 4,968
CrystalDiskMark Random 4KQ1 Read / Write (MB/s)	**92 / 331**	89 / 310	90 / 294
Max Temp Under Load (C)	**72**	78	89
Gigabyte per $ (GB)	**13.42**	7.69	9.17
Sequential Read MB/s per $ (MB/s)	**52.88**	47.51	47.91

Best scores in bold. Our test bed consists of an Intel Core i9-14900K, 32GB of Corsair Dominator Titanium @ 7200, an Nvidia GeForce RTX 4080, Corsair H150i AIO, and an Asus Z790 Dark Hero. Max Temp recorded via HWMonitor during benchmarking process.

SPECIFICATIONS

Variants	Heatsink
Form Factor	M.2 2280
Interface / Protocol	PCIe 4.0 / NVMe
Flash Memory	232-Layer TLC NAND Flash
Sequential Read	7,400 MB/s
Sequential Write	7,000 MB/s
Random Read	1180K IOPS
Random Write	1440K IOPS
Endurance (TBW)	1400
Warranty	5 Years Limited Warranty

32GB Corsair Dominator Titanium DDR5

All the bells and whistles

LET'S FACE IT, if there's one thing Corsair should be good at, it's memory. The company built itself off the back of the great memory race of the '90s and early '00s, and has since held a dominant position in the industry. Look at any industrial sector that's reliant on memory chips, and Corsair probably supplies the majority of the DRAM for it.

It's a similar story in the PC gaming sector, with the company having some serious flagships. Back in early 2012, when Linus Tech Tips was just two dudes filming hardware unboxings, the company launched perhaps its most ambitious memory kit to date in the form of its DDR3 Dominator Platinum line.

PC gaming had been well cemented for some time now, but it was just starting to see an explosion in the DIY space. People wanted more glitz, glamor, perspex case windows and RGB illumination, and the higher-performing memory kits and components that came with that. Thus, the Platinum line was born. Clean black designs, top-end NAND Flash, and pristine, beautiful aluminum (ironically) heat spreaders, complete with white LED underglow illumination, and even the option to install LED lightbars on top if you really wanted to make your rig pop.

They cost the earth and came with high frequencies, but for many, this halo product was the crème de la crème of 'Check out my rig, it's really cool, I've got too much money, see my expensive RAM'.

With DDR4 came Dominator Platinum RGB, complete with an updated look and capellix LEDs, super-small, excessively bright illumination for your machines, and of course, with Ryzen CPU's Infinity Fabric bound to the same frequency as the memory controller, and thus your DRAM, suddenly speed mattered once again, and so the race continued.

Roll on through DDR5 and into 2023, and at Computex of that year, Corsair announced its successor, the Dominator Titanium. Complete with a new design, AMD and Intel variants, removable heatbars on top that you could customize and 3D print your own with (the design file is actually on the product page), enough RGB illumination to make the Las Vegas Sphere shrink in fear (probably), and of course, all the performance to boot.

Take our kit here, for example. This fairly 'mid-range' kit comes in at 7200 MT/s, complete with C34 latency for a 9.44 ns real-world latency, plus 32GB of dual-channel capacity to back it up—it's fairly pedestrian compared to some of the Titanium kits available. 48GB (2x24GB) at 8,000 MHz C38 is at the top end of speed for $285, with 96GB (2x48GB) of 6000 MT/s available at the top end of capacity (for an eye-watering $510) and everything in between. All of them lie in that 10ns range, though, and are heavily tested before leaving the Corsair factory.

Our kit holds its own at 32GB and 7200 MT/s, and its performance beats everything we've tested it against, but is that worth the cost? Right now, this kit will set you back $235. For similar specs from Patriot, TeamGroup, or G.Skill, you're looking at $125-135. Even Corsair's Vengeance lineups are $160.

So, is it worth it? If you're after pure performance then the smart choice is to go for something cheaper. But if you need the absolute best-looking kit out there, with some of the tightest timings and performance on the market, then this is the kit to go for. **–ZAK STOREY**

BENCHMARKS

	32GB (2x16GB) Corsair Dominator Titanium DDR5 @ 7200 MT/s	32GB (2x16GB) XPG Lancer Blade RGB DDR5 @ 6000 MT/s
SiSoftSandra Overall Memory Score (Index/kPT)	**2.49**	2.27
SiSoftSandra Memory Latency (ns)	**73**	80
SiSoftSandra Memory Bandwidth (GB/s)	**80**	69
PCMark10 - Express (Index)	**7,162**	6,624
10GB WinRAR Archive Time (Seconds)	**115**	116
Puget Bench - Adobe Photoshop (Index)	**8,150**	7,550
Total War: Warhammer III (avg/min fps)	**191.3 / 148**	**191.3** / 147
Max Temp Under Load (Celsius)	**43.5**	51.0
Real World Latency (ns)	**9.44**	10.00
Gigabyte per $ (Index)	0.15	**0.30**

Best scores in bold. Our test bed consists of an Intel Core i5-14600K, Asus Z790 Dark Hero motherboard, an Nvidia GeForce RTX 4080, Corsair H150i AIO, and an Adata Legend 960 Max PCIe 4.0 SSD. All gaming tests were performed at 1080p, on the highest preset. XMP is enabled.

VERDICT 9

32GB Corsair Dominator Titanium DDR5

⊞ **TITANIC PROPORTIONS** Top-tier performance; Incredibly stylish; Unmatched capacities and speed.

⊟ **THE TITANIC** Expensive.

$235, www.corsair.com

SPECIFICATIONS

Capacity	32GB (2x16GB)
Channels	Dual
DDR Standard	DDR5
Frequency	7,200 MT/s
CAS Latency	34
Operating Voltage	1.45V
Warranty	Limited Lifetime

Benq X3100i

Chunky 4K brilliance

PROJECTION is often overlooked as a format for a good gaming display, and with good reason. Over the years, they've been held back by a multitude of factors: poor brightness, space requirements, lens burn-in from static imagery (OLED says hello), low resolution, price, and of course, refresh rate.

There's a lot to put off any would-be buyer, particularly when looking at their next big-screen purchase. Times have changed, however, and projectors have come a long way since those days of yore. Yes, they're still remarkably expensive pieces of equipment, but the tech you get with them these days very much justifies the cost. Well, almost.

Take this Benq X3100i 4K gaming projector. It's robust and chunky, complete with a 3,300 lumens brightness, 3,840x2,160 resolution, 600,000:1 contrast ratio, 1.07-billion color support, and a bulb lifetime of around 20,000 hours in normal use (that's 2.28 years of continuous 24/7 usage). Combine that with 100 percent DCI-P3 coverage, compatibility with Android TV as standard, and super-low latency modes, as well as a high-refresh 1080p mode, and this thing is onto a winner.

The long and the short of it is that you can take this beautiful piece of kit, bang it on a 150-inch screen, and game to your heart's content, either at 4K 60 fps or 120 fps 1080p. What's not to love? Well, a few things, actually.

PAYING THE PRICE

First and foremost is the cost, because this thing is not cheap. Straight out of the gate, the price sits at a snug $2,399. Yep, that's some serious cash right there. For that amount of money, you could nearly pick up not one, but two Asus ROG Swift OLED PG48UQ 48" 4K OLED displays. It's a big investment up front, and that remains perhaps the humble projector's biggest hurdle to overcome.

This is very much a luxury item. The reality is that it's for a gaming room, theater, or massive living room, where you drop that projection screen once or twice a week at most, or with your buddies on a weekend, smashing around on your console of choice. It isn't a daily driver, not by a long shot (although we'd love to hear from anyone who uses it that way). That's inherently its biggest issue: when you can pick up a 48" OLED for half the price, and even larger OLED TVs for similar prices, that 150" glamor fades away.

Then there's the size of the thing. It certainly isn't small; this boxy boy has some serious dimensions. It clocks in at an eye-watering, almost square 10.7 x 8.4 x 10.2 inches at 15 lbs. If you're mounting it to your ceiling, make sure it's high enough out of the way that you're not going to headbutt the thing, as it's certainly not quite as rectangular as we'd like. On top of that, the layout of the unit, including access buttons and mounting solutions, makes it rather frustrating to use, particularly when you're dialing it in with the, err, dials. Yes, it does have a remote, but lens configuration requires you to physically adjust the unit by hand.

Ultimately, it's a beautifully potent projector that competes well against similarly marketed projection devices. But if you're after amping up your gaming setup, or looking for something a little more day-to-day friendly, you might be better off looking elsewhere. –ZAK STOREY

VERDICT
7

Benq X3100i

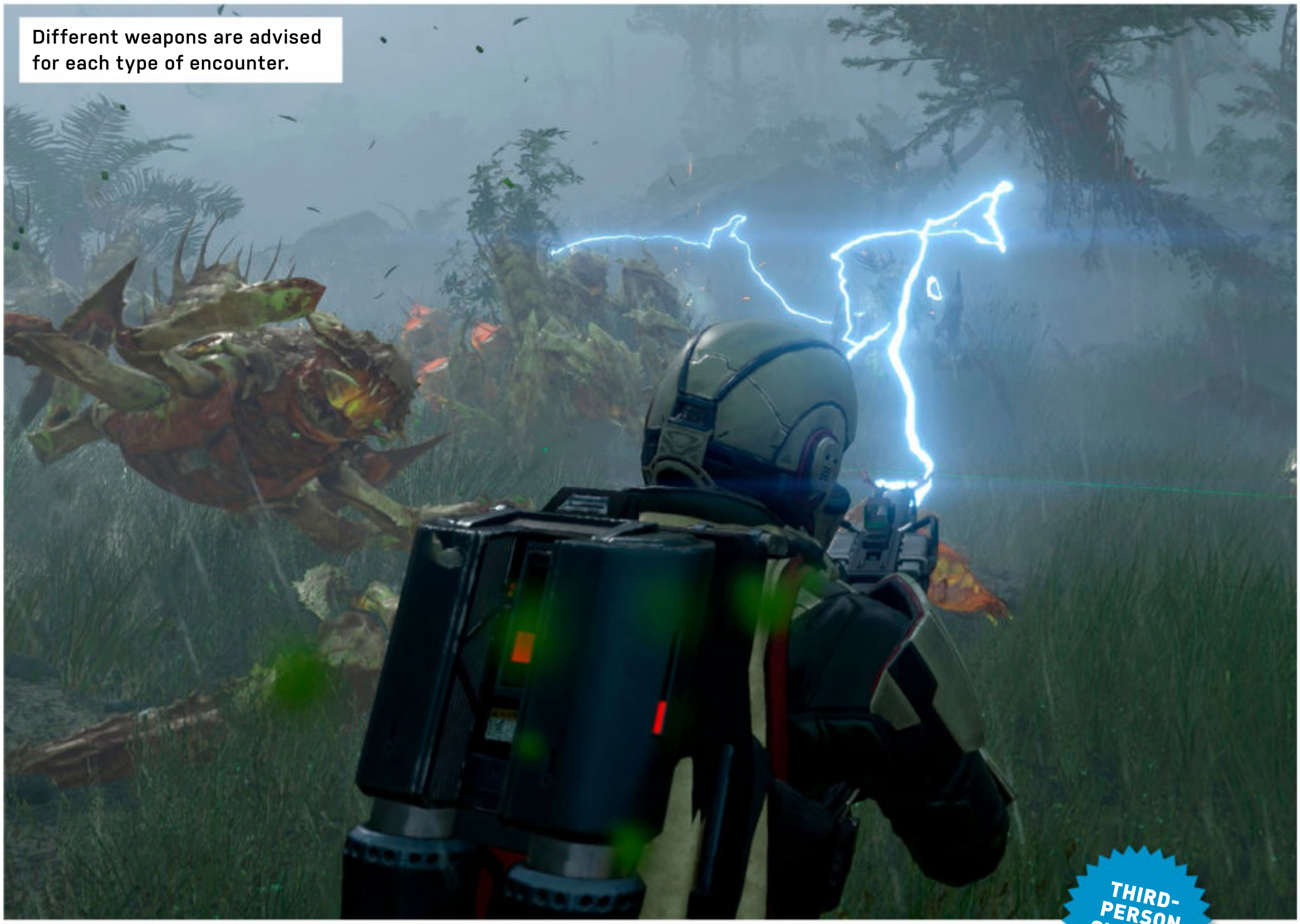
➕ **SHINE BRIGHT LIKE A DIAMOND** Impeccable color replication; Broad array of resolutions, refresh rates, and latency; Clean design.

➖ **DULL AS DISHWATER** Costs a lot of money; Seriously bulky.

$2,400, www.benq.com

SPECIFICATIONS

Resolutions	4K60 @ 16.7,s, 1440p120 @ 8.3ms, 1080p240 @ 4.2ms
Display Colors	1.07 Billion
Contrast Ratio	600,000:1
Brightness	3300 Lumens
Light Source Life	20,000 - 30,000 Hrs
Max Screen Size	150"
Zoom Ratio	1.3x
Throw Ratio	1.15 - 1.50
Projection Offset	110%
Lens Shift Vertical	40 - 60%
Connectivity	x2 HDMI 2.0b External, 1x HDMI 2.0b Internal, 1x USB Type A, 1x RS232 in, 1x 3.5mm Jack, 1x 12V Trigger



Different weapons are advised for each type of encounter.

THIRD-PERSON SHOOTER

Helldivers 2

Bombastic, funny, and challenging, but still a bit buggy

PICTURE THE SCENE: four soldiers make a desperate scramble for their dropship on an alien planet, pursued by enormous, dagger-clawed bugs. Machine gun fire rattles, green goo erupts, the landing pad teems with beasts as the quartet piles through the boarding hatch, and their ride blasts off at the last available second. It could be a Hollywood action sequence, but in *Helldivers 2*, it's merely the end of another mission.

Indeed, it's amazing just how often a *Helldivers 2* sortie climaxes in screaming, skin-of-the-teeth heroics. It remains exciting time after time because that Hollywood ending is never guaranteed. Maybe you get tagged yards from completing your great escape, or maybe by a spray of bullets from a wheeling teammate.

Speaking of teammates, this is a four-player squad shooter (solo play is possible, but not much fun), where every element harmonizes explosively, resulting in scenes that really could have been choreographed for the movies. In a sense, they were. *Helldivers 2* is unashamedly a mash of sci-fi action film tropes, with a large slice of *Starship Troopers* on proud display, sprinkles of *Aliens* and the *Terminator* series on top.

One of the most consistently brilliant concepts in *Helldivers 2*, in fact, is that support always arrives from the sky, launched by your personal starship, which hangs like a satellite above your position. In many ways, this sequel is a remake of the first *Helldivers* with added live service progression and a switch of perspective, from top-down to over-the-shoulder. But that switch is a genuine game changer, both because it makes the fights so much more up close and personal, and because of your connection with the heavens, as drops from above pepper the battlefield.

It's not any one element of *Helldivers 2* that makes it sing, however. They all conspire together. With the enemies, the numbers are huge—with frame rate drops being rare—closing in like xenomorphs nesting in a reactor. But the specifics of each kind also force you to react differently, making you run, stand firm, or dive to the dirt, scatter grenades, or whip out a shotgun.

SETTING THE SCENE

The mission design, meanwhile, is involving and varied, from destroying bug nests or bot factories to grabbing soil samples or preparing the launch of an ICBM, objectives span multiple stages, which send you between traversing the sizeable maps to holding positions while stabbing inputs into terminals, manually moving machinery, or waiting for processes to complete.

The visuals and audio are spot on, too. Each planet has a distinct personality, while the bugs are reliably disgusting, and bots are as menacing as the *Terminator*

© SONY INTERACTIVE ENTERTAINMENT

Solo play is possible in *Helldivers 2*, but where's the fun in that?

The game retains a sense of the dramatic.

SES Keeper of Iron
OPERATED BY X_xAlan15x_X
ACQUISITIONS
Froggy
Level 9 | CADET
dx--sfb
Level 10 | CADET
X_xAlan15x_X
Level 12 | CADET
jonbailes150
SPACE CADET
Level 8
5136 / 5850
Support is never far away thanks to the aid of your own personal starship.

Enemies have different strengths and weaknesses, forcing you to tailor your tactics.

Some scenes look like they really could have been choreographed for movies.

Each planet has a distinct personality, while the bugs are reliably disgusting.

influence implies. The sound is the star, though, from pitch-perfect gunfire, reload clacks and explosions, to the chitter and squeal of insects, the perfectly timed "Eat this!" and "For democracy!" barks of your team, and a score that's equal parts jingoistic and dramatic. It's almost a shame to turn on your microphones, although definitely advisable.

Despite all that, after 20 hours of play, a sense of grind does begin to kick in a little. The quantities of XP and currencies required to level up and grab more powerful stratagems, weapons, and armor push you towards higher difficulty levels, which are tough to manage without well-organized and equipped teams. It can feel like a bit of a catch-22 situation, in which you need better gear to tackle their challenge, but it's difficult to get that gear until you do.

That sense of slow progress isn't helped by all the technical hitches. Losing your connection as you make that run for the dropship after a 30-minute mission is infuriating, as is arriving home to find that you've not been awarded the points you'd earned. Developer Arrowhead is clearly paying attention, and the bugs are being squashed, though the sheer number of people playing *Helldivers 2* is still causing capacity problems. Here's hoping all that is sorted by the time you read these words. **–JON BAILES**

© ARROWHEAD

VERDICT

8

Helldivers 2

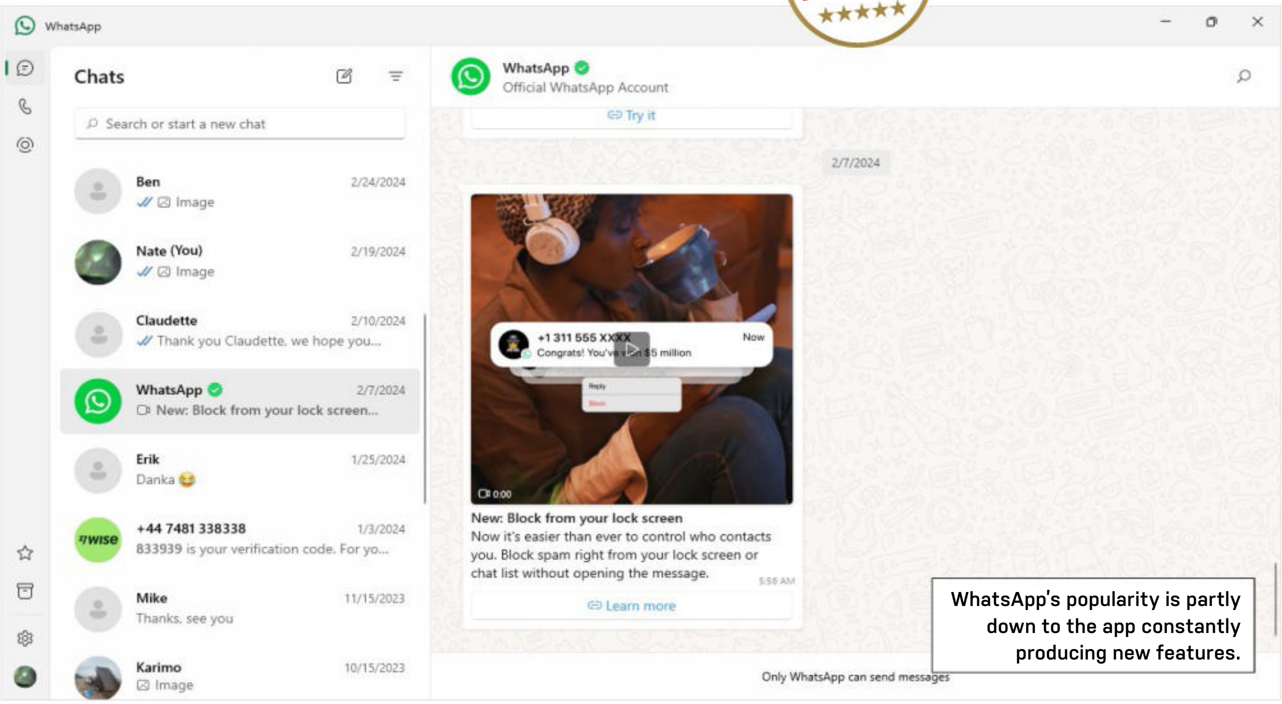
JOIN UP NOW! Thrilling sci-fi mash-up; Fabulous audio and dialogue; Great mission design.

KNIFE IN A NUKE FIGHT The grind eventually sets in; Early technical glitches have been infuriating.

RECOMMENDED SPECS CPU, Intel i7-9700K or AMD Ryzen 7 3700X. GPU, NVIDIA GeForce RTX 2060 or AMD Radeon RX 6600 XT. RAM, 16GB. 100GB storage.

$39.99, https://www.arrowheadgamestudios.com/aboutarrowhead/games/helldivers/
M-rated

HEAD TO HEAD WINNER ★★★★★



WhatsApp

Chats

Search or start a new chat

Ben 2/24/2024
Image

Nate (You) 2/19/2024
Image

Claudette 2/10/2024
Thank you Claudette, we hope you...

WhatsApp 2/7/2024
New: Block from your lock screen...

Erik 1/25/2024
Danka 😂

+44 7481 338338 1/3/2024
833939 is your verification code. For yo...

Mike 11/15/2023
Thanks, see you

Karimo 10/15/2023
Image

WhatsApp
Official WhatsApp Account

Try it

2/7/2024

+1 311 555 XXXX Now
Congrats! You've won $5 million

0:00

New: Block from your lock screen
Now it's easier than ever to control who contacts you. Block spam right from your lock screen or chat list without opening the message. 5:56 AM

Learn more

Only WhatsApp can send messages

WhatsApp's popularity is partly down to the app constantly producing new features.

WhatsApp vs Signal

Which secure messaging app is the winner?

WHATSAPP AND SIGNAL have a lot in common: they're both messaging apps that support text, voice, and video. They can also make use of group chats, status updates, and share much of the same codebase for encrypting communications.

Still, WhatsApp's the pick for billions of people, while Signal is in the low tens of millions. This said, due to Signal's focus on privacy, there's often a spike in downloads in the wake of privacy scandals, such as the security bug discovered by Twitter engineer Foad Dabiri in 2023, where WhatsApp secretly activated the microphone on his Pixel phone.

WHATSAPP

At the time of writing, WhatsApp has over 2.8 billion active users, and is expected to pass 3 billion in 2024, making it by far the world's most popular messaging application. That's not bad for an app that started out in 2009 as a simple way to update statuses on iPhones.

The app currently supports text, voice and video calls to individuals and groups of up to 512 people. There are also thousands of 'Community' groups, which are simply a larger version of group chats.

Mobile versions are available for Android and iPhone, though there's no dedicated app for iPad. PC users can sign in to WhatsApp web via a QR code to a mobile device, or install the dedicated desktop app for Mac or PC.

One of WhatsApp's biggest draws is that it's constantly introducing new features. Chief among these is 'WhatsApp Business', which allows small companies to exchange messages with customers. This is a paid service, though the messenger is free for personal use.

Since June 2023, WhatsApp also supports 'Channels'. This allows entities like news organizations, content creators. and other organizations to send public broadcasts to any number of users. Other recent innovations include short voice messages, as well as 'disappearing' messages for extra security.

Speaking of security, in 2016, WhatsApp (in partnership with Open Whisper Systems) announced that end-to-end encryption was now universally applied to all communications across the platform. This includes a feature for users to verify each other's public keys to avoid MITM (Man in the Middle Attacks).

In theory, this means that if WhatsApp's servers were hacked or seized, there'd be no way to decrypt any messages, voice, or video calls. However, as WhatsApp is proprietary software, there's no way to tell exactly how this is implemented.

Organizations like the EFF (Electronic Frontier Foundation) have also expressed concern about WhatsApp privacy, particularly since the app's acquisition by Facebook owners Meta in 2014.

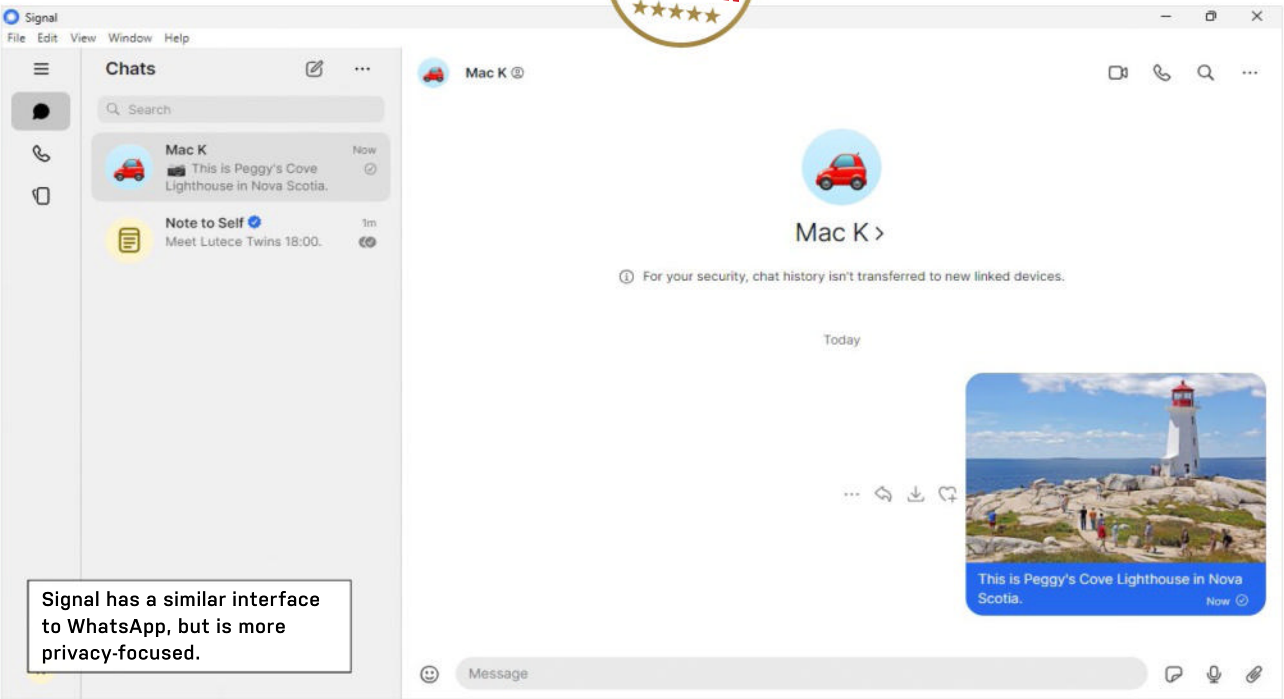
Still, in 2021 Meta drew criticism after announcing a privacy policy that would allow certain WhatsApp user data to be shared with Facebook. This policy doesn't apply in the EU, where it's illegal under GDPR. WhatsApp has previously complied with requests from law enforcement to provide information like who users have contacted and how often they used the app.

On the plus side, WhatsApp deploys the Signal Protocol and SRTP to encrypt messages and calls, which are themselves cryptographically sound. End-to-end encryption also applies to any chats you choose to back up to the cloud. This allows for easy and secure transfer of chat history across all devices.

In late 2023, WhatsApp also introduced support for logging into multiple accounts via the same app (previously, users had to register and access accounts via a single cellphone number). Voice calls are now supported for up to 32 users.

© WHATSAPP

HEAD TO HEAD WINNER



Mac K
This is Peggy's Cove Lighthouse in Nova Scotia.

Note to Self
Meet Lutece Twins 18:00.

Mac K >

For your security, chat history isn't transferred to new linked devices.

Today

This is Peggy's Cove Lighthouse in Nova Scotia.

Signal has a similar interface to WhatsApp, but is more privacy-focused.

SIGNAL

Signal has seen a surge in popularity in recent years. The app is a combination of two separate projects (RedPhone and TextSecure), designed for secure voice and text messaging respectively. It was released in 2015 under the auspices of security consultant Moxie Marlinspike and Stuart Anderson of Whisper Systems. In 2018, the WhatsApp co-founder joined the newly formed Signal Technology Foundation as a non-profit.

To this day, Signal subsists largely on donations, and the app itself is FOSS (free and open-source software). There are mobile versions for both Android and iOS, and unlike WhatsApp, Signal runs quite happily on an iPad. Although there's no web portal, desktop versions are available for Windows, Mac, and Linux.

If you've used WhatsApp before, you'll be very much at home with Signal's UI, considering the app also supports text, voice, and video comms with individual users and groups of up to 40 people.

All communications are secured via end-to-end encryption using the eponymous Signal Protocol for messages and an implementation of WebRTC for voice and video. Like WhatsApp, users can verify each other's public keys to prevent MITM attacks. The platform also supports disappearing messages. As with WhatsApp, you can send secure messages to yourself. Signal takes security so seriously that when you sign in from a new device, your chat history is not copied across. Nevertheless, you can save your chat history to the local device.

Co-creator Moxie Marlinspike has claimed that no user metadata is stored on Signal's servers, with the exception of the last time a user connected. Even group information like the name, members, and profile pictures are stored on user devices, meaning Signal has 'zero knowledge' of content. This is most likely why the app has received praise from the likes of the EFF and Edward Snowden.

The app also deploys 'domain fronting' to bypass blocking attempts in countries where secure messengers are restricted, like Iran and Cuba.

Besides better privacy, Signal's other major difference from WhatsApp is that it doesn't continually introduce new features. It has a 'Stories' mode, but major influencers and organizations can't address all users via broadcast channels.

Since 2022, Signal has had an integrated wallet for sending and receiving payments. However, currently the only accepted medium is cryptocurrency MobileCoin. Back in 2019, Facebook and WhatsApp flirted with the idea of a cross-platform cryptocurrency named 'Libra' to facilitate payments, but the project was abandoned in 2020. This said, Signal has no equivalent to WhatsApp Payments, which enjoys the support of banks like SBI and Axis for WhatsApp Business transactions, though these are currently confined to India, Brazil, and Singapore.

To register with Signal, users must use the Android or iOS version of the app and have a valid phone number, although this doesn't necessarily have to be the same as that of the SIM card in your device.

In February 2024, Signal began rolling out usernames in beta versions. A number is required for registration, but instead of giving that number to other contacts, you can provide your chosen username for others to start a conversation via the app.

It's unlikely that anything will knock WhatsApp off its pedestal, especially given the plethora of cool features. If this is important to you, then go with the flow. If you value privacy more, then Signal offers the best secure messaging solution, hands down. **–NATHAN JORDAN**

VERDICT 9

WhatsApp

➕ **WHATSUP** An amazing number of features from the most popular messenger in the world.

➖ **WHATSDOWN** Closed-source, proprietary software can be bad for user privacy.

Free, https://www.whatsapp.com

VERDICT 9

Signal

➕ **SIGNALRIGHT** Open-source, privacy-focused with verifiable end-to-end encryption.

➖ **SIGNALERT** Limited features with unnecessary cryptocurrency wallet.

Free, https://signal.org

© SIGNAL

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

> All-AMD Build
> Windows Where?
> UK Pricing Woes

AMD on a budget

I was wondering if there was any reason why you haven't done a $1,300 AMD build for a while, and if there was any likelihood you'll be doing one in the near future? That would be very much appreciated. I have the budget, and think it's time for me to pull the trigger! **– Andrew S.**

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS: Thanks for the request and the build challenge—we always love to receive them! We haven't done an AMD build at that budget for a while, you're right, but with AMD's new Ryzen 7 7800G chip (reviewed on page 78), or even the $549 Radeon RX 7900 GRE graphics card released this month (read more on page 11), now could be the time.

The 7800G would make an interesting basis for a low-cost build well below the $1,300 mark. It might just have the makings of the first modern PC that makes sense without a dedicated GPU, what with its eight powerful Zen 4 cores and relatively powerful (for an integrated GPU) 780M graphics. That said, it's less compelling if paired with a proper graphics card—you'd be better off with a Ryzen 7 7700X which gives you more pure CPU performance for less cash.

However, the Radeon RX 7900 GRE definitely does have the makings of a great basis for a $1,300 build. At $549, it's priced surprisingly close to the Radeon RX 7800 XT to the extent that the 7800 now feels a little redundant at its $499 MSRP. What's very likely is that the 7800 XT will have to come down a little in terms of actual retail pricing to remain relevant. Either way, watch this space for our future builds. In the meantime, check out our Blueprints pages on pages 96-98 each issue. Both the budget and mid-range builds listed there are in your rough ballpark budget.

What's with the cheap Windows licences?

I love the magazine. I started years ago reading Boot by purchasing it at magazine stands—then on a business flight several years ago, the person next to me was reading *Maximum PC*. I said that looks good, so he gave me one of the issues he had with him. I was hooked.

Anyway, on to my question. I've built my computers for several years. My current PC is from 2015 with a GPU upgrade that I made a few years ago. Yeah, it's old, but it does function pretty well. My gaming is not heavy duty—*Fallout 4*, Civ VI, and *Gunner, HEAT, PC!*. I'm lining up components for a new build using a 12GB Nvidia 3060. One thing I keep noticing on your builds in the Budget/Mid-Range/Turbo section (I look at this every issue) is the Windows OEM price—where are you getting it for $30? Every site I use for pricing my parts has Win11 OEM for around $124. Are you guys holding someone's hard drive hostage for a price consideration?

Again, I love the magazine. Keep up the good work. **–M. Reitz**

JEREMY LAIRD RESPONDS: We've mentioned this in Comments a few times, and it's covered in this issue's Builder's Manual (page 46), but the typical sources we use when building one-off systems for family and friends are g2a.com and kinguin.net. Using G2A as a current example, Windows 11 Home will set you back $26 for a Win11 Home key before taxes. Generally, they average around $32 or so on the whole.

Of course, in simple technical terms, you don't need a license to download and install Windows 11, only to activate it. It's something Microsoft tolerates, despite it being against the strict terms of the software license. Whether it's legal to install and run Windows without activation is something of a gray area. Our interpretation is that it's strictly illegal, but tolerated.

What we can say for sure is that you do lose some features and functionality after 60 days without activation. For instance, you won't be able to personalize the desktop background, window title bar, taskbar, and Start color, change the theme, customize menus and taskbar, or the lock screen.

You'll also periodically get messages asking

↘ submit your questions to: editor@maximumpc.com to activate your copy of Windows, plus a 'watermark' indicating that Windows has not been activated. This might annoy you, as the message may show up in the middle of your work, but there are various workarounds for many of the feature losses.

The biggest issue with an unlicensed copy of Windows 10 is not being able to personalize it. All other features will work just like on a licensed copy of the OS. So not being able to personalize and that nagging watermark are the main issues when using Windows 10 without activation.

Why are graphics cards so pricey in the UK?

I get your magazine to read in the UK, but I wish I enjoyed American prices here. In the UK, your $599 4070 Super is equivalent to £473. In reality, that 4070 Super costs me over £800. I think I'll just stick to my RTX 4060 Ti, which cost me £385 at Christmas, and serves me well for 1080/1440 gaming. In the UK/Europe, hardware prices are just taking the proverbial, and not worth the print on the price sticker.

–G. Eadie (Edinburgh, Scotland)

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS:
We're not sure where you're looking for RTX 4070 Supers in the UK, Glen, but they're widely available from popular retailers like Overclockers.co.uk and Scan from £590. Of course, that's still a lot more than the typical $599 US price, but then the US price doesn't include sales tax, while all UK pricing includes the country's local value added tax, which is rated at a fairly punitive 20 percent. Take that off, and you end up with a figure of around £490 before tax, which is pretty much in line with US pricing.

RTX 4070 SUPER

RTX 4070 Super pricing in the UK probably isn't quite as bad as Glen fears.

©NVIDIA

All that said, it is an unfortunate reality that pricing of many PC components and products in the UK, and indeed across much of Europe, has tended to be a little higher than the US in recent years, even taking into account local sales taxes.

It's not always clear why that's the case. It could simply be a more competitive retail environment in the US. Whatever, while components are pricier in the UK than the US, it's probably not quite as big a gap as you are implying.

With all that covered, the next question is whether you should upgrade from your 4060 Ti. That probably depends whether you're willing to go through the process of selling your existing GPU, and how much you can get for it. A quick scan of eBay suggests a used 4060 Ti should command at least £250, and perhaps as much as £300, so you'd get most of your money back.

You'd still have to find nearly £300 on top to move up to a 4070 Super. Apart from enjoying immediately better frame rates and having the realistic option to make the jump to 4K in many games, the other advantage of the 4070 Super is longevity. The 8GB version of the 4060 Ti, especially, is soon going to run into problems with VRAM allocation. It simply doesn't have enough for the most demanding games.

In the end, it comes down to how important gaming is to you, and how painful it is to come up with the extra cash. If you love gaming and can reasonably afford it, we'd say to go for it. The RTX 4070 Super is a very nice GPU at a pretty reasonable price.

1440p versus 4K

I've been gaming at 1440p for what seems like forever, having upgraded from a 60Hz 27-inch panel to a 144Hz model a couple of years back. I can't decide whether now is the time to go all the way to 4K or whether the benefits for gaming aren't actually all that. What does the great *Maximum PC* hive mind think? **–Mark P.**

JEREMY LAIRD RESPONDS:
Ah yes, the great conundrum of our age, 1440p or 4K for gaming? One thing we can say is that if you want to stick with a 27-inch panel for whatever reason, maybe because desk space is at an absolute premium, don't bother with 4K. For gaming, the increased visual detail isn't all that, comparing 1440p to 4K on a 27-inch panel.

If you can spare the space, then it makes sense to go 32 inches at 4K. You're still getting much better pixel density than a 27-inch 1440p panel, plus the larger scale of a 32-inch screen. However, with the added image quality comes a lot more GPU load.

With today's graphics cards, you're looking at a minimum of $600 on an RTX 4070 Super to get decent 4K frame rates, and we'd say the new RTX 4070 Ti Super is a more realistic option for smooth gameplay.

All of this means we'd actually recommend an alternative screen solution. Go for a 34-inch ultrawide. You get the same pixel density as a 27-inch 1440p panel, but the added width makes for much-improved immersion. It really is a thrill to game on a 34-inch ultrawide. At the same time, the ultrawide option only increases GPU load by about 35 percent, where full 4K more doubles it. In other words, you can probably switch to the ultrawide without an immediate GPU upgrade. Guy and I both love the Alienware AW3423DW OLED at this size and resolution, and as we've said many times in these pages, once you game on an OLED, there really isn't any turning back.

Missing Super Hero

I've been following your recent builds featuring the new Nvidia RTX Super cards, but the one I'm actually interested in, the RTX 4080 Super, hasn't featured!. It's $200 cheaper than its predecessor, so put me out of my misery—is it worth buying!?

–J. Common

EDITOR-IN-CHIEF, GUY COCKER, RESPONDS:
Worry not, the 4080 Super will be reviewed and featured in our cover build next issue.

At the risk of spoilers, we like the 4080 Super, but the performance increase is small, and the price is now merely what it should have been from the start. For the full verdict and benchmarks, check out our next issue!

THE BUILDS

THIS MONTH'S STREET PRICES...

BUDGET

IF THIS MONTH has taught us anything, it's that the market is unstable. We're seeing price fluctuations all over the place—not surprising given we've just got past the holiday rush, and this time is notorious for big businesses to struggle to push those sale goals, but still, these builds have been tricky to fine-tune.

Take our budget build as an example—the Ryzen chips are all over the place. You can theoretically pick up a Ryzen 5 7600X for less than the 7600 we have here. In fact, our little chip has gone up $12 compared to last month, but the X doesn't come with a cooler. If you've got an AM4/AM5 cooler spare, it's worth the jump, but otherwise, you'll end up spending more.

The new 8000 series G chips might look tempting, particularly given they're on TSMC's latest 4nm manufacturing process, but the amount of PCIe lanes and cache they give up isn't worth the price drop, particularly if you're running a dedicated GPU, and any amount of PCIe storage. Great for integrated GPU gaming or home theaters, but less so for everything else.

For our Intel build, the 14500 is still the chip to beat. It's gone up in price again by $15, but given the next lowest chip, the 14400, is $10 less than this one, and has four less cores, it's still just too good an opportunity to pass up. We've swapped to an MSI Ventus 4060 to offset that loss a touch.

For the joint picks, there's a new Patriot Viper, this time with lower-frequency memory, moving from 5600 to 5200, but it has a tighter CAS latency, bringing real-world latency down (it's quicker than the last kit, and cheaper). We've opted for a Solidigm P41 Plus SSD for our primary drive. It saves $5 against the price of the old drive, but is still more expensive than last issue.

Despite the market shenanigans and memory woes, our AMD build has gone up by only $13, and our Intel build impressively has gone up by just a dollar. We're happy with that.

AMD INGREDIENTS

PART		PRICE
Case	Corsair 4000D Airflow	$95
PSU	600W Thermaltake Toughpower GX2 80+ Gold	$65
Mobo	Asus Prime X670-P ATX AM5	$200
CPU	AMD Ryzen 5 7600	$229
GPU	XFX Speedster Swift 210 Core RX 7600 8GB	$260
RAM	16GB (2x8GB) Patriot Viper Venom DDR5 @ 5200 **NEW**	$65
SSD 1	1TB Solidigm P41 Plus PCIe 4.0 M.2 **NEW**	$65
SSD 2	1TB Adata Legend 800 PCIe 4.0 M.2	$64
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32

Approximate Price: $1,075

INTEL INGREDIENTS

PART		PRICE
Case	Corsair 4000D Airflow	$95
PSU	600W Thermaltake Toughpower GX2 80+ Gold	$65
Mobo	MSI Pro Z790-S WiFi ATX LGA1700	$170
CPU	Intel Core i5-14500	$240
GPU	MSI Ventus 2X Black OC RTX 4060 8GB **NEW**	$285
RAM	16GB (2x8GB) Patriot Viper Venom DDR5 @ 5200 **NEW**	$65
SSD 1	1TB Solidigm P41 Plus PCIe 4.0 M.2 **NEW**	$65
SSD 2	1TB Adata Legend 800 PCIe 4.0 M.2	$64
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32

Approximate Price: $1,081

MID-RANGE

FOLLOWING ON FROM the budget range's chaos, prices on our mid-range systems aren't much better. Our AMD build has seen some savage price cuts, with only minor help from us.

The Ryzen 7 7700X got a $45 price cut, bringing it to an eye-wateringly low $289—the cheapest we've seen it for some time. Alongside that, our joint case of choice, the H7 flow, hit a smooth $100. Some items did see a price increase, however. Corsair's memory and PSU have gone up by $10-15 in places. We've dropped the RMe PSU in favor of Thermaltake's Toughpower GF1 2024 edition. It's still fully modular, fully 80+ gold rated, and brings an extra 100W of headroom to the table.

Memory has also seen a big shake-up. We're starting to see a phenomenal amount of 6000 MT/s C30 kits hit the market, all of which seem to be priced around $90. We've gone with two new kits because of it: the Adata XPG Lancer kit for our AMD build, coming in at $95, and Team Group's T-Create Expert for $93 on our Intel system. Both are incredibly classy kits, although you'll be forgoing RGB lighting if you do go that route.

Speaking of Intel, our motherboard of choice, the MSI Z790 Gaming Pro WiFi, has gone up by $20. Unfortunately, there are no better-value mobos right now, certainly not with this level of features and connectivity. There are cheaper boards if you're on a shoestring, but bear in mind that you'll be giving up expandability. To get around that, we've swapped out our GPU to a Zotac unit, pulling $15 back off the price as well.

Be careful, particularly with memory. As we mentioned, there's a number of 6000 C30 kits out there, but we did spot a 6000 C42 kit at $91 and a C30 kit at $92 with identical heatsinks and naming schemes, so pay attention to the fine print. Otherwise, it's been a tight month for these builds, with our AMD system dropping by $77, and our Intel system up by—again—a dollar.

AMD INGREDIENTS

PART		PRICE
Case	NZXT H7 Flow	$100
PSU	850W Thermaltake Toughpower GF1 2024 80+ Gold **NEW**	$90
Mobo	MSI PRO X670-P WiFi ATX - AM5	$225
CPU	AMD Ryzen 7 7700X	$289
Cooler	Corsair A115 Air Tower	$100
GPU	ASRock Radeon RX 7700 XT Challenger OC	$430
RAM	32GB (2x16GB) Adata XPG Lancer Blade DDR5 @ 6000 **NEW**	$95
SSD 1	1TB Corsair MP600 PRO LPX M.2 PCIe 4.0 SSD	$92
SSD 2	1TB Adata Legend 800 M.2 PCIe 4.0 SSD	$64
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32
Approximate Price:		**$1,517**

INTEL INGREDIENTS

PART		PRICE
Case	NZXT H7 Flow	$100
PSU	850W Thermaltake Toughpower GF1 2024 80+ Gold **NEW**	$90
Mobo	MSI Z790 Gaming Pro WiFi ATX	$210
CPU	Intel Core i5-14600KF	$285
Cooler	EK AIO Basic 360 - 360mm AIO	$129
GPU	Zotac Gaming Twin Edge RTX 4060 Ti 8GB **NEW**	$380
RAM	32GB (2x16GB) Teamgroup T-Create Expert DDR5 @ 6000 **NEW**	$93
SSD 1	1TB Corsair MP600 PRO LPX M.2 PCIe 4.0	$92
SSD 2	1TB Adata Legend 800 M.2 PCIe 4.0 SSD	$64
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32
Approximate Price:		**$1,475**

TURBO

UNSURPRISINGLY given the size of these price tags, we're seeing some significant shift here too, although one build in particular got a hell of a shock compared to the other.

Let's start with the AMD rig. Our Ryzen 9 7950X has gone up by $31, but as it's the best of the best, we can't let that one go. Additionally, the X670E mobo from last issue received a hefty price hike. We've swapped to the Asus Prime X670E Pro WiFi to counter that, and that's helped keep to $300, without losing any major features or connectivity. Aside from that, the cooling went up by $7, and our 4TB SSD of the month got a $16 price bump.

The Enthoo Pro 2 continues to go strong, and fell by another $10, possibly signaling that it's soon becoming end-of-life. Phanteks is trying to shift units, but a deal is a deal, and we're happy to take it. Our memory kit and PCIe 5.0 SSD solutions also fell by $10 each respectively.

We've shifted to a new 4TB SSD across both systems in what seems like a constant battle to keep that quad-terabyte drive sweet. This time, opting for the Crucial P3 Plus yet again to provide our additional storage. Team Group also has a similarly priced 4TB drive if you're looking for an alternative brand, too.

As for our Intel system, the 14900KF received a price bump, although not quite as dramatic as the 7950X, and only increased by $10. The biggest change by far, however, was the GPU, which skyrocketed by an incredible $350, all the way up to $1450. In fact, there's only one RTX 4080 Super under $1,100 at the moment—our MSI GPU. It's a shame, given that Nvidia's RRP was $999. Don't think you can grab an RTX 4080 cheap instead either, as every card we found was above $1,110 as well. In fact, Nvidia's own FE cards and every other $999 card is currently out of stock.

We're not sure what's causing the bump in pricing. Whether that's scalpers or another Crypto rush is uncertain, but it's worth keeping an eye on, and possibly holding off until things return to normal. Either that, or it's the greatest marketing ploy we've ever seen. As for total pricing, our AMD system has gone up by $19, while our Intel system is pleasingly down by $41.

AMD INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$140
PSU	Super Flower Leadex Platinum SE 1200W - 80+ Platinum	$160
Mobo	Asus Prime X670E Pro WiFi - AM5 **NEW**	$300
CPU	AMD Ryzen 9 7950X	$548
Cooler	NZXT Kraken Elite 360 RGB - 360mm AIO	$284
GPU	Sapphire Nitro+ RX 7900 XTX 24GB	$1,060
RAM	64GB (2x32GB) TeamGroup T-Create Expert @ 6000 C34	$175
SSD 1	2TB Corsair MP700 PCIe 5.0 M.2	$250
SSD 2	4TB Crucial P3 Plus PCIe 4.0 M.2 **NEW**	$235
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32
Approximate Price:		**$3,184**

INTEL INGREDIENTS

PART		PRICE
Case	Phanteks Enthoo Pro 2 Tempered Glass	$140
PSU	Super Flower Leadex Platinum SE 1200W - 80+ Platinum	$160
Mobo	Gigabyte Z790 Aorus Elite AX-W ATX	$369
CPU	Intel Core i9-14900KF	$540
Cooler	NZXT Kraken Elite 360 RGB - 360mm AIO	$283
GPU	Gigbayte Gaming OC RTX 4080 Super 16GB **NEW**	$1,050
RAM	48GB (2x 24GB) G.Skill Trident Z5 RGB DDR5 @ 6800 CL34	$170
SSD 1	2TB Corsair MP700 PCIe 5.0 M.2	$250
SSD 2	4TB Crucial P3 Plus PCIe 4.0 M.2 **NEW**	$235
OS	Windows 10 Home 64-bit OEM (Windows 11 Compatible)	$32
Approximate Price:		**$3,229**

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